AD-A036 485 BELL HELICOPTER TEXTRON FORT WORTH TEX F/G 13/9
RESULTS OF ENVIRONMENTAL TESTING OF MODIFIED OH-58A TAIL ROTOR --ETC(U)
OCT 70 D J WARD DAAJ01-70-C-0057

UNCLASSIFIED 206-097-005 USAAVSCOM-TR-77-3 NL

1 OF 1
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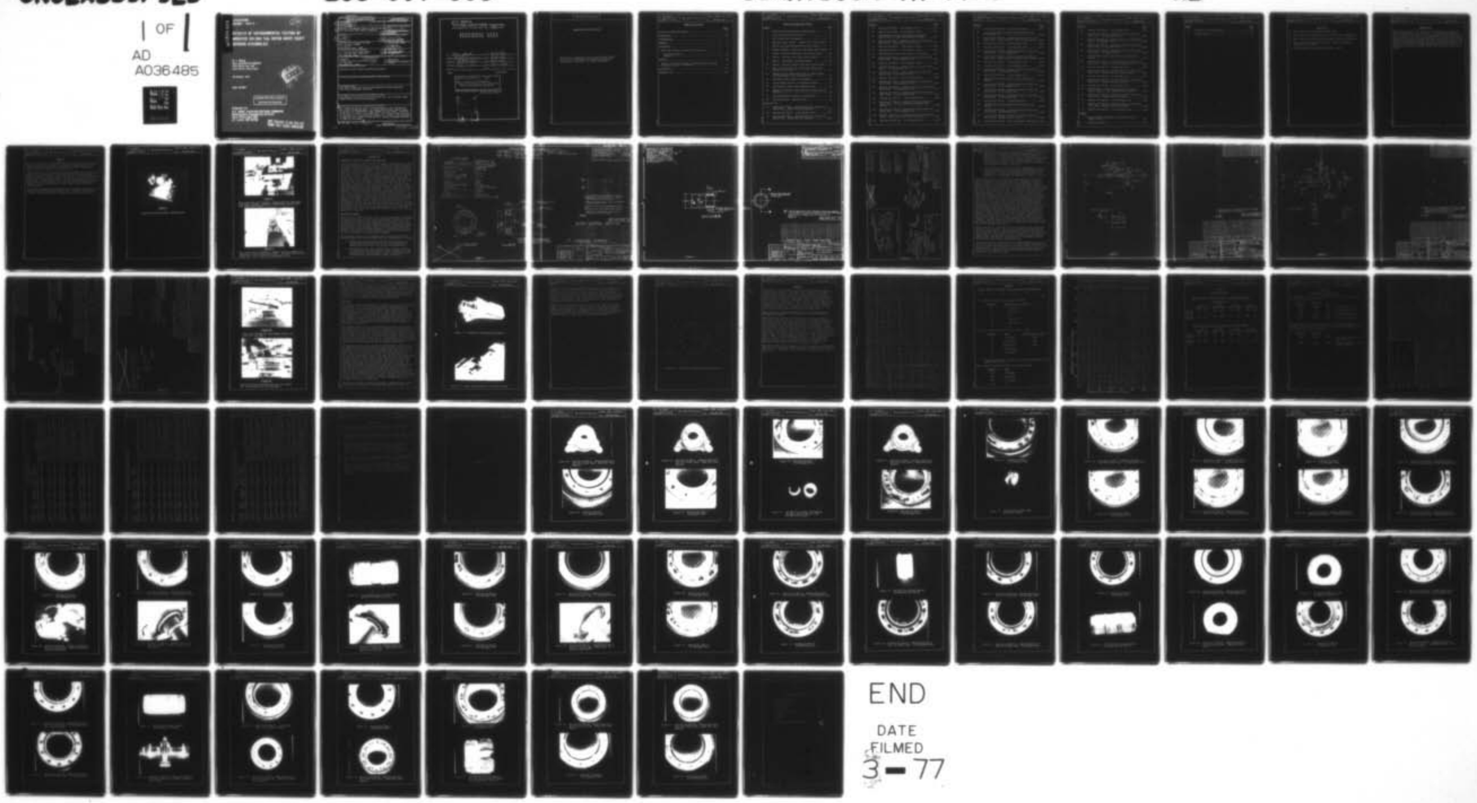

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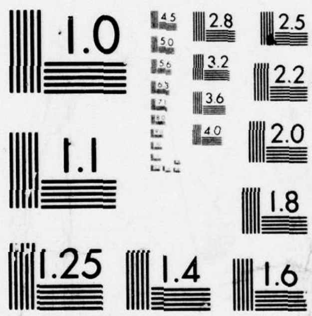
3-77



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

USAAVSCOM
REPORT - TR77-3

RESULTS OF ENVIRONMENTAL TESTING OF MODIFIED OH-58A TAIL ROTOR DRIVE SHAFT BEARING ASSEMBLIES

D. J. Ward
BELL HELICOPTER COMPANY
Post Office Box 482
Fort Worth, Texas 76101

30 October 1970

FINAL REPORT

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED

Prepared for
U.S. ARMY AVIATION SYSTEMS COMMAND
Maintenance Engineering Division
Post Office Box 209
St. Louis, MO 63166

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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8. CONTRACT OR GRANT NUMBER(s): DAAJ01-70-C-0057

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P.O. Box 486
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):

18. SUPPLEMENTARY NOTES:
This report presents the results of environmental testing accomplished under Product Improvement Task 69-4F

19. KEY WORDS (Continue on reverse side if necessary and identify by block number):
Environmental test, Closed Circuit Wind Tunnel Test, Static Testing, Spring Loaded Bearing, Collar, Shield, B_{10} Life

20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

This report presents the results of testing OH58A tail rotor bearings with dust shields and modified seals. The spring loaded bearing clamp up feature incorporated into 206-040-344-1 hanger assembly was also tested. Testing was accomplished in a closed circuit wind tunnel. Air filtration media test dust was introduced into the test machine periodically to produce a test environment of high velocity air laden with sand and dust. Bearing arrangement exhibited a 5X B_{10} Life Improvement.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

054 200

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APPROVED	C. W. Bowler	DATE	8-21-70
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Approved	C. T. Harvey	Date	10-30-70

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TITLE RESULTS OF ENVIRONMENTAL TESTING OF MODIFIED OH-58A TAIL ROTOR DRIVE SHAFT BEARING ASSEMBLIES

PREPARED UNDER CONTRACT DAAJ01-70-C-0057(2E)
P.I.P. Task 69-4F

7842 56976 REV 266

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TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

Table | Page

REFERENCES

1. PIP Task 69-4F, BHC Report 206-099-999.

2. Bell Helicopter Engineering Work Authorization 206HA9.4F.

3. Bell Helicopter Engineering Work Authorization 206DA1.12E.

4. Bell Helicopter Engineering Orders 206HA-5, 206HA-15, 206HA-16, and 206HA-17.

5. Bell Helicopter Drawing 206-040-304, sheet 2.

INTRODUCTION

This report presents the results of environmental testing accomplished under P.I.P. Task 69-4F. The purpose of the test was to evaluate the effect of modified seals and the addition of dust shields, on the life of the 206-040-339-3 tail rotor hanger bearings in severe dust/sand operating environment, and to evaluate the spring-loaded bearing clamp-up feature incorporated into 206-040-344-1 hanger assembly by Engineering Order 206HA-5. The basis for comparison of these modifications was the results of identical testing on existent OH-58A tail rotor bearing assemblies.

SUMMARY

Service failures of the 206-040-339-3 tail rotor hanger bearings have precipitated a product improvement program wherein a replacement bearing and hanger assembly have been designed and environmentally endurance tested (Fig. 1).

Implementation of the environmental test program was accomplished through the fabrication of a closed circuit wind tunnel test machine (Figs. 2 and 3). Eight bearings were tested concurrently, four each on two parallel shafts, in the test section of the test machine at a speed of 5700 rpm. Air filtration media test dust (SAE J726A) was introduced into the test machine periodically to complete the test environment of high velocity air laden with sand and dust.

The bearing arrangement developed under the P.I.P. task (Fig. 1) exhibited a 5X B_{10} life improvement over standard 206-040-339-3 bearings under the conditions imposed by the test environment.

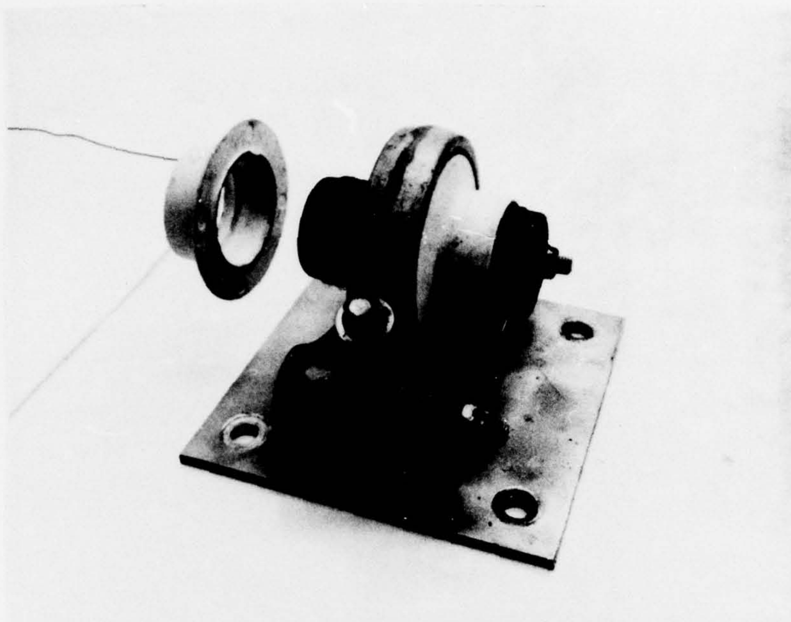


Figure 1

Proposed Bearing Assembly Configuration

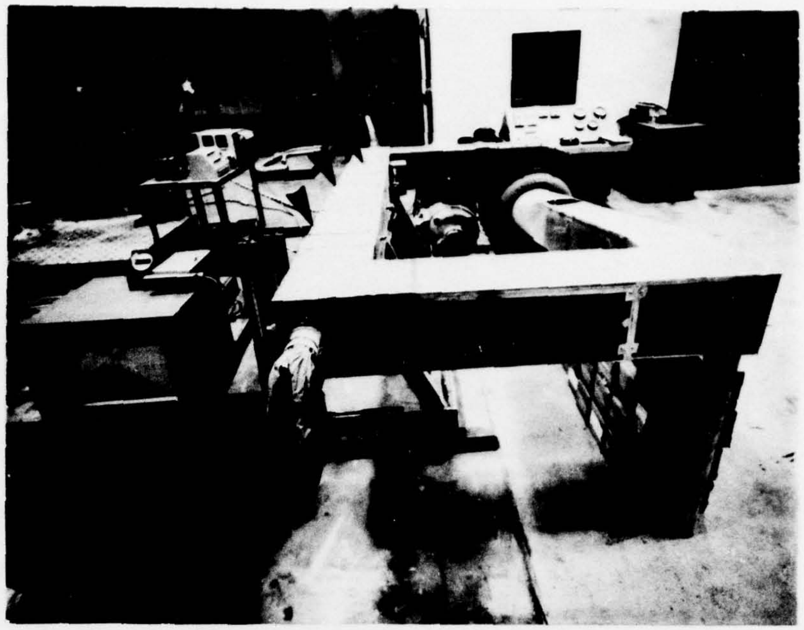


Figure 2

Test stand with top in place. Arrows indicate plexiglass inspection windows. Honeywell temperature recorder and test timer are on left.

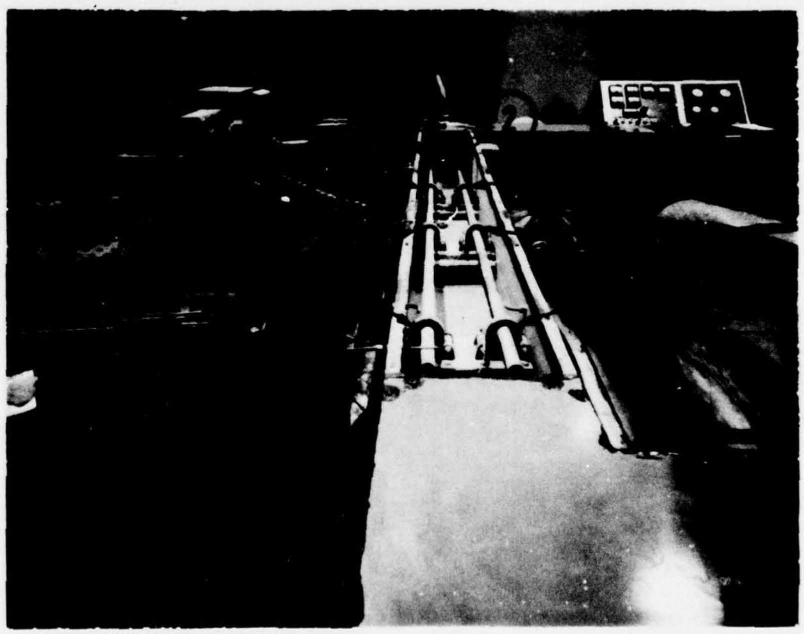


Figure 3

Test stand with top removed. Numbers indicate sequence of numbering of test bearing positions. Also note wind velocity manometers, pitot tubes and thermocouple wires.

DISCUSSION

BENCH TEST STAND AND METHOD OF OPERATION

The test stand was built out of 10" square conduit laid out into a rectangular closed duct. Air was circulated within the duct by a 30" diameter centrifugal blower driven by a 30 hp Varidrive. A means of metering test dust into the duct was incorporated on the outlet side of the blower. The test shafts were so located that the test dust impinged on bearings #1 and #2 directly from the side. The test dust then turned and passed over the remaining bearings in an axial direction impinging directly on the seals. The shaft curvature attitude and alignment simulated the installation on the OH-58A as closely as possible. The portion of the shaft aft of the last bearing hanger was cut off to facilitate installation in the test stand. Two of these shafts were installed in the test stand side by side. The test shafts were driven from their forward splines from a modified fan sheave through a metallic flexible coupling. Special felt seals were used where the modified fan sheave passed through the duct. A 3/4 hp induction motor was used to drive the test shafts at 5700 rpm. Thermocouples, installed at the split line of each bearing hanger, were monitored one minute out of every six by a 24 point Honeywell Recorder. The recorder was set to stop the test if any bearing reached 250°F. Ambient temperature in the duct was measured by a probe type thermocouple installed over the bearings at positions #7 and #8. The air velocity in the duct was measured by a pitot tube installed in the side of the duct. The pitot was connected to two water monometers reading static and dynamic pressure in the duct.

Testing Procedure

This test was conducted under dense dust environmental conditions which were far more intense than encountered in flight, in order to reduce the mean time to failure of the bearings. However, since no direct conclusions comparing service life to test life are possible, the test was designed to produce comparable confidence levels on the observed test lives of standard production bearings and the new shielded bearings. The improvement ratio of new to standard test lives should be equalled or exceeded in service applications in similar environments.

All bearings tested in this program were procured from Fafnir Bearing Company and were divided into four combinations as follow:

1. Production 206-040-339-3 bearings (Fig. 4) mounted on 206-040-315-1 collars (Fig. 5) and in 206-040-344-1 hanger assemblies (Fig. 6) (Baseline Configuration).

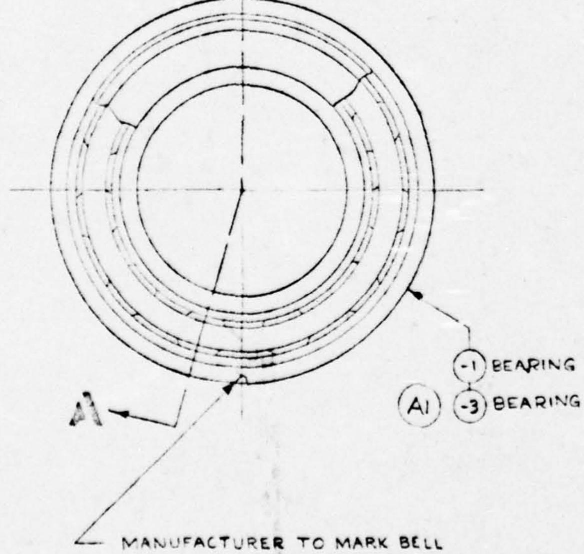
2. EXP 18426A-5G bearings (206-040-339-3 bearing modified to incorporate an .010 smaller inside diameter seal and cadmium-plated outer diameter) mounted on 206-040-315-1 collars and in 206-040-344-1 hanger assemblies.

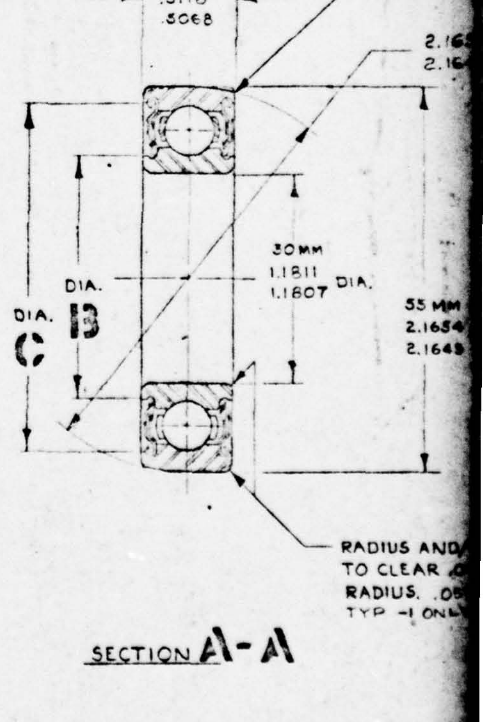
HOUSING: -1 ONLY	BORE	2.1640 - 2.164[illegible]
	MATERIAL	AL. ALY.
	FIT	.0004T TO .00[illegible]
HOUSING: -3 ONLY	BORE	2.1649 ~ 2.1654
	MATERIAL	AL ALY
	FIT	.0005L ~ .0005T

INSTALLATION D

BEARING DATA

		-1 & -3
	MANUFACTURER	FAFNIR BEARING CO. 5
	MANUFACTURER CODE IDENT. NO.	21335
	MANUFACTURER DESIGNATION (-1)	P 910C N PP E-9202 C
A1	MANUFACTURER DESIGNATION (-3)	P 9106 N PPB E-9202 B1
	TYPE OF BEARING	SINGLE ROW - BALL, SEALED
	RACE CURVATURE: INNER	52 % (REF.)
	OUTER	54% (REF.) C
	NUMBER OF BALLS	11
	BALL DIAMETER	9/32
	BALL MATERIAL	AMS-7440
	BALL TOLERANCE GRADE (AFBMA)	25
	INTERNAL RADIAL CLEARANCE	.0006 - .0010
	FACE RUNOUT: INNER	—
	OUTER	—
	AXIAL PLAY	.008 MAX.
	GAGE WEIGHT	5.5 LBS.
	TOLERANCE CLASS	ABEC-1
	BASIC DYNAMIC CAPACITY (AFBMA)	2290 LBS.
	RING MATERIAL	AMS-6440 OR 6441
	RETAINER TYPE	2 PC. PRESSED ~ SPOT WELDED
	RETAINER MATERIAL	STEEL
	DIA. "B"	1.373 (REF.)
	DIA. "C"	1.968 (REF.)
	PITCH DIAMETER	1.673
A2	LUBRICANT TYPE	ALFA-MOLYKOTE 343X
	LUBRICANT QUANTITY	1.5 ± .20 GRAMS
A1	HEAT TREAT SPEC 2	HT-18, PARA 2 & HT-22, PARA 2 C





SECTION A-A

~~*Furnished under United States Government Contract Number [illegible]. Shall not be either [illegible]~~

Figure 4

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED
A	1) SEE EO 206EA-134(2) INC EO 206EA-134F(3) ADDED N/A REQ FOR TH-57A(4) ADDED SOURCE QUALIFICATION, ADDED PROPRIETARY DECAL	4-9-68	D. CLVLND.
B	(1) SEE E.O. 206EA-1518	10-1-68	J. B YOAK
C	SEE E.O. 206EA-1874	11-18-68	J. STROUD

ATION DATA (REF. INFO. ONLY)

40 - 2.1645   SHAFT: DIAMETER —— 1.1816 - 1.1811
ALY.   MATERIAL —— STEEL
04T TO .0014T   FIT —— .0009 T TO LINE TO LINE
49 ~ 2.1654
ALY
05L ~ .0005T

.005 / .020 RADIUS OR CHAMFER -3 ONLY

2.1654 / 2.1649 SPHERICAL DIA -3 ONLY

DIA.

55 MM
2.1654 / 2.1649 DIA. -1 ONLY

RADIUS AND/OR CHAMFER TO CLEAR .039 MAX. FILLET RADIUS. .059 MAX BREAKOUT TYP -1 ONLY

C 8. Any change to this unit or components thereof, after initial Bell approval, involving [illegible], material [illegible] must be submitted to Bell Helicopter [illegible] and approved in writing prior to delivery [illegible].

C 7. [illegible] THIS DRAWING [illegible] LISTED [illegible] HELICOPTER COMPANY [illegible] AND APPROVAL [illegible] HELICOPTER COMPANY [illegible] BY U.S. ARMY AVIATION MATERIEL COMMAND.

6. SOURCE QUALIFICATION REQUIRED PER REPORT NO. 206-099-045.

5. APPROVED MANUFACTURER PURCHASE BEARINGS FROM THESE FLAGGED SOURCES ONLY.

4. BEARING APPEARANCE QUALITY MUST CONFORM TO MFG'S STD. FOR AIRCRAFT QUALITY.

3. BEARINGS MUST HAVE FULL AND SYMMETRICAL RACES.

2. BEARINGS MUST BE STABILIZED FROM -65°F TO +300°F

1. BEARING TO BE INSPECTED TO LIMITS SHOWN ON THIS DRAWING BEFORE STOCKING.

NOTES:

206-040-339 C

SOURCE CONTROL DRAWING

	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	STOCK SIZE	MATERIAL	MATERIAL SPEC
A1	206-040-339-3	BEARING	(SEE BEARING DATA)		
	206-040-339-1	BEARING	(SEE BEARING DATA)		

LIST OF MATERIAL OR PARTS LIST

EWA 206EA-8.8   NO. 6283

DASH NO	NEXT ASSY	USED ON
-3	206-040-301	TH-57A
-3	206-040-304	206A-1
-3	206-040-304	OH-58A
-3	206-040-301	206A
-1	206-040-801	TH-57A
-1	206-040-301	206A

APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

EXCEPT AS NOTED

C TURNER 11/8/65

11/16/65

11/19/65

11/19/65

11/19/65

11/23/65

11/30/65

BELL HELICOPTER COMPANY

BEARING, BALL, SEALED - HANGER, TAIL ROTOR DRIVE

CODE IDENT NO 97499   SIZE D   206-040-339

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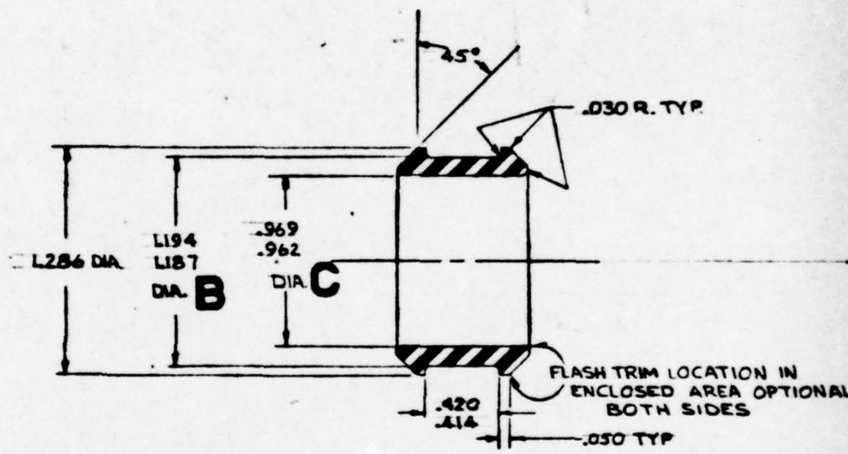
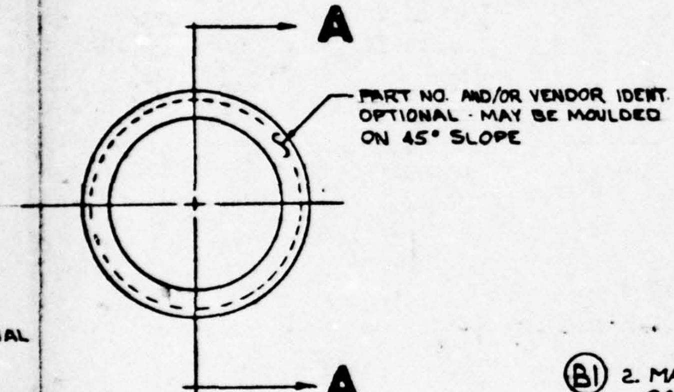


SECTION A-A

Figure 5

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	(1) INC. E.O. 206A2898 (2) ADDED PROPRIETARY NOTE DECAL & ADDED 206A, TH-57A, OH-58A & 206A-1 N/A REQ.	6-8-68	STAPPER
B	(1) SEE E.O. 206 EA-1880; (2) REMOVED PROPRIETARY DECAL.	1-2-69	STROUD
C	ADDED PROPRIETARY DECAL	9/29/69	CLVLND.



N IN
OPTIONAL

(B1) 2. MAY BE PURCHASED FROM CRESSKILL/STILLMAN RUBBER CORP., 176 FOREST AVENUE, ENGLEWOOD, NEW JERSEY. CODE IDENT NO 91041

1. DIA. "B" MUST BE CONCENTRIC WITH DIA. "C" WITHIN .004 T.I.R.

NOTES:

206-040-315 C

QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	STOCK SIZE	MATERIAL	MATERIAL SPEC	
	206-040-315-1	COLLAR	MOULDED	RUBBER	MIL-R-7362 TYPE II	COMP. B

LIST OF MATERIAL OR PARTS LIST

EWA 206A-919

DASH NO	NEXT ASSY	USED ON
-1	206-040-304	206A-1
-1	206-040-304	OH-58A
-1	206-040-301	TH-57A
-1	206-040-301	206A
-1	206-040-300	206/HO-4
	APPLICATION	

HEAT TREAT —
FINISH SPEC 206-947-002

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ANGLES
.XX ± .010
.X ± .01
± 1/2°

MACHINED SURFACES ✓ EXCEPT AS NOTED (PER MIL STD 10)

DRAFTSMAN CANAVESPE 3-14-62
DESIGNER CARLSON, F.J.
CHECKER J. Davidson 3-20-62
STRESS F. CARLSON 3-23-62
WEIGHTS
C.E. ... for ... 3/27/62
R.L. Moore 3/27/62
PROJECT
... 3/27/62
CUSTOMER

BELL HELICOPTER COMPANY
A DIVISION OF BELL AEROSPACE CORPORATION
POST OFFICE BOX 482 FORT WORTH 1, TEXAS
A TEXTRON COMPANY

TITLE
COLLAR, BEARING RETAINING
TAIL ROTOR DRIVE

CODE IDENT NO 97499 | DWG SIZE D | DWG NO 206-040-315

SCALE 2/1 | CONTRACT NUMBER DA23-204-TC-1659 | SHEET 1 OF 1

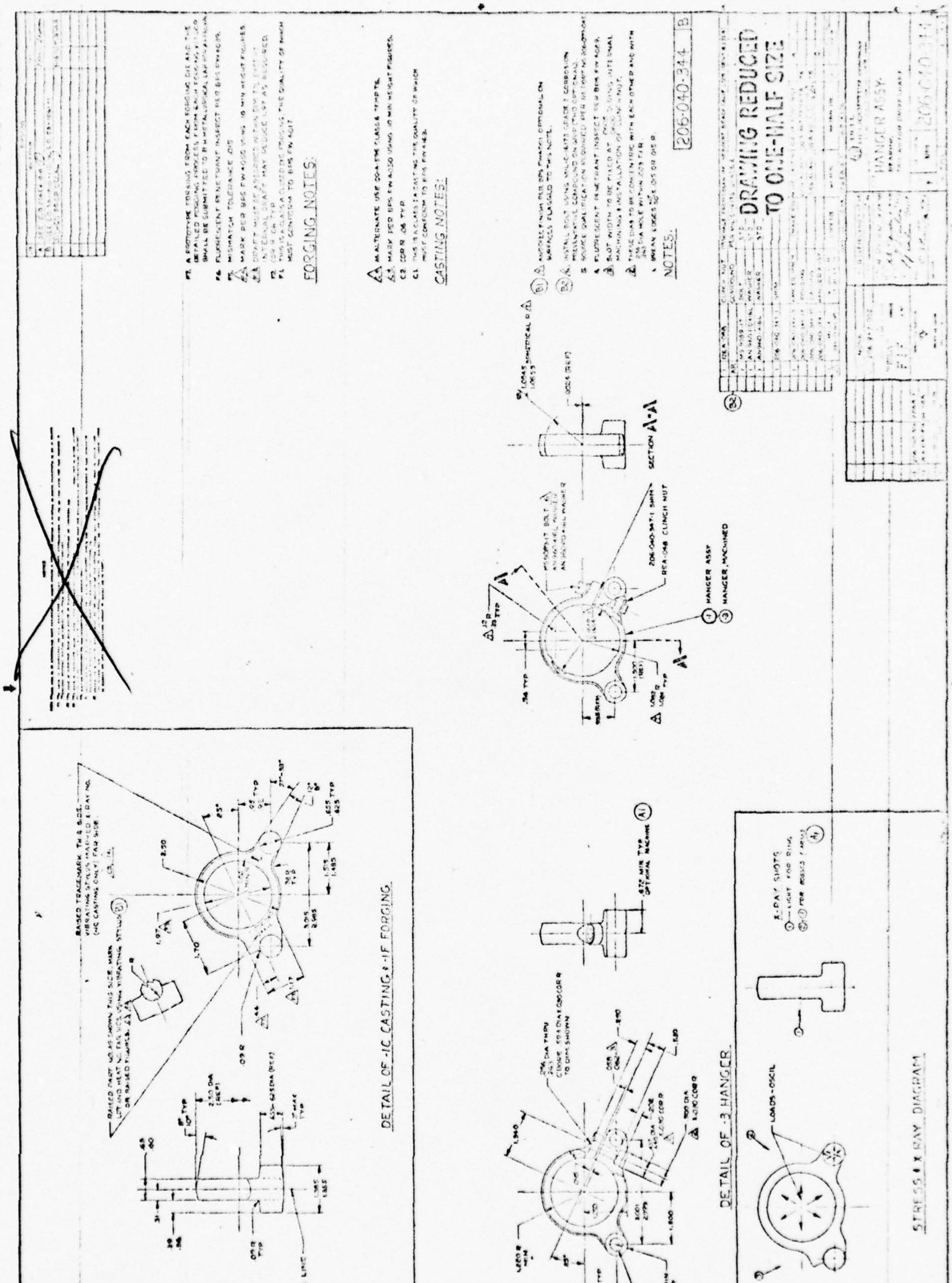

DRAWING REDUCED TO ONE-HALF SIZE
206-040-344 B
HANGER ASSY
FORGING NOTES:
CASTING NOTES:
NOTES:
SECTION A-A
DETAIL OF -1C CASTING & -1F FORGING
DETAIL OF -3 HANGER
STRESS & X RAY DIAGRAM

Figure 6

3. EXP 18426-3G bearings (206-040-339-3 bearing modified to incorporate cadmium-plated outer diameter) mounted on 206-040-350-1 collars (Fig. 7) with 206-040-349-1 shields (Fig. 8) and in 206-040-344-1 hanger assemblies modified to Engineering Order 206HA-5, incorporating a spring-loaded clamping feature with the addition of 206-040-351 and 206-040-352 (Figs. 9 and 10).

4. EXP 18426A-5G bearings mounted on 206-040-350-1 collars with 206-040-349-1 shields and in 206-040-344-1 hanger assemblies modified to Engineering Order 206HA-5, incorporating a spring-loaded clamping feature with the addition of 206-040-351 and 206-040-352 (Figs. 7 and 8).

Testing of all bearing assemblies was accomplished by running them at 5700 rpm in the wind-tunnel-like apparatus shown in Figures 2 and 3. Air cleaner test dust conforming to SAE test specification J726A was introduced on the following schedule. Upon starting test at 0800, add 1/2 pound fine dust, and at noon add 1/2 pound coarse dust. The test was shut down before leaving at night. The dust/air mixture was directed into the side of bearing positions 1 and 2, then over 3 and 4 at 25 mph, over 5 and 6 at 42 mph, and over 7 and 8 at 78 mph. Airflow was produced by a 30-inch centrifugal fan powered by a 30 hp Varidrive (Fig. 11). Temperature of each bearing assembly was measured at the split line of the hanger assembly by thermocouples routed out of the test section to a 24-point Honeywell temperature recorder set to record one minute in six (Fig. 12). Due to the stabilizing effect of the large air mass flow passing over the test bearings, only minor temperature variations could be observed between individual test bearings. Even at the point of bearing failure, only 20 to 30 degrees Fahrenheit temperature increase could be detected. It was necessary, therefore, to maintain close scrutiny of the test in order to detect failure by a minor change in a bearing's temperature level, or by an increase in sound level, or by physical signs of catastrophic failure. Ambient temperature in the test box stabilized at 140 to 150 degrees Fahrenheit. Bearing temperatures were generally 140 to 170 degrees Fahrenheit.

After testing was concluded, it was discovered that a miscalculation in the layout of the stand had caused the curvature of the test shafts to be slightly different from the curvature of the OH-58A tail rotor drive shaft. See Table 1. The comparison between test configurations is still valid, but the effect of wind velocity may be less influential in establishing failure distribution than results would indicate.

In addition to its evaluation in the running portion of the test, static testing was performed on the spring-loaded clamping feature of the 206-040-344-1 hanger assembly modified to Engineering Order 206HA-5. The purpose of this portion of the test was to determine the adequacy of the spring loaded bearing hanger to retain the bearing outer ring.

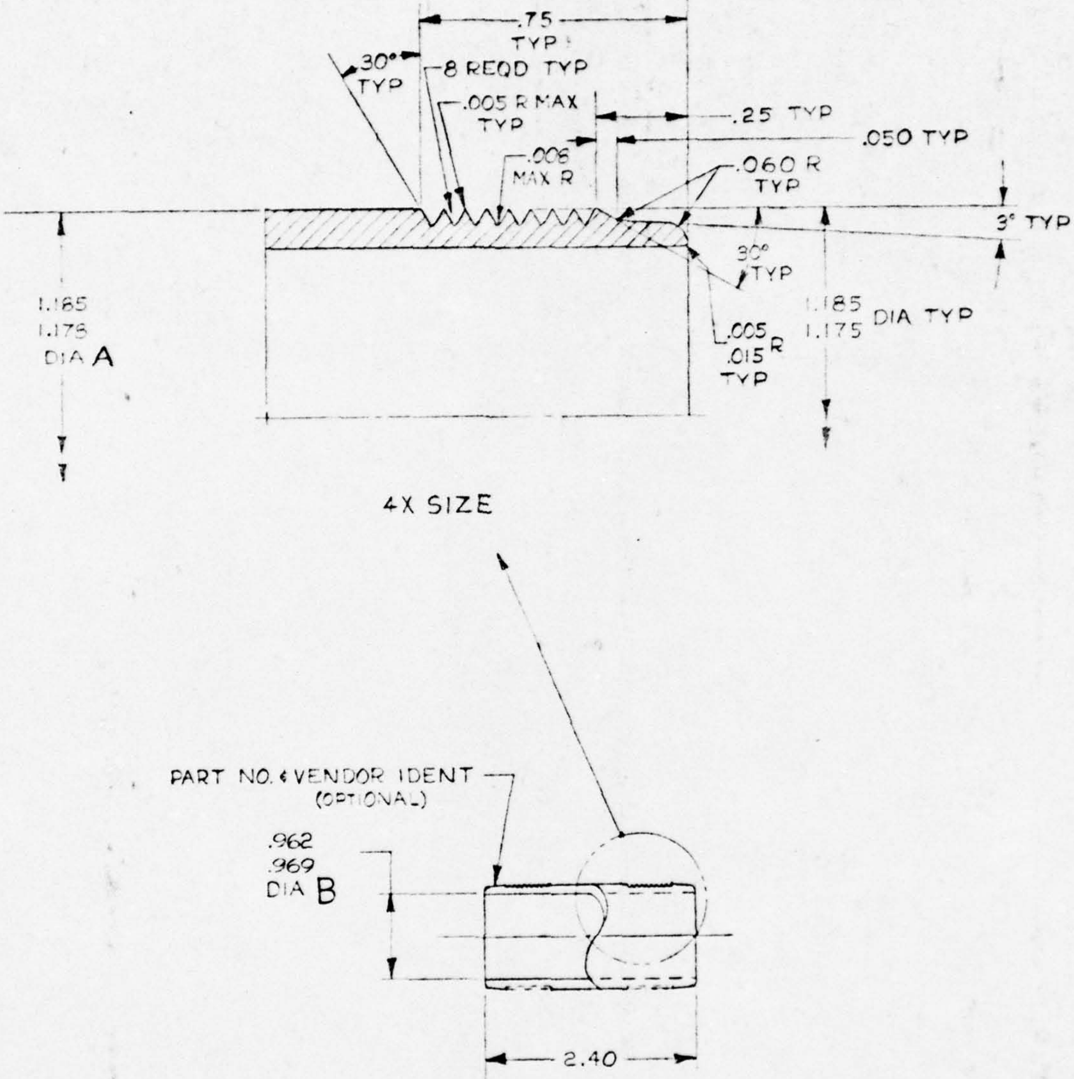

.75
TYP
30°
TYP
8 REQD TYP
.005 R MAX
TYP
.006
MAX R
.25 TYP
.050 TYP
.060 R
TYP
3° TYP
30°
TYP
1.185
1.175
DIA A
1.185
1.175
DIA TYP
.005
.015
R
TYP
4X SIZE
PART NO. & VENDOR IDENT
(OPTIONAL)
.962
.969
DIA B
2.40

Figure 7

2

1. DIA A & DIA B NOT TO TAPER MORE THAN .003 & TO BE CONCENTRIC WITHIN .004 T.I.R.

NOTES:

206-040-350

PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	STOCK SIZE	MATERIAL	MATERIAL SPEC.
206-040-350-1	COLLAR	MOLDED	RUBBER	MIL-R-7362 TYPE II

PARTS LIST WO 617 EWA 206HA 9 4 F

DASH NO.	NEXT ASSY	USED ON
-1	EO 206HA-4	TEST

APPLICATION

HEAT TREAT ~
FINISH SPEC ~

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS: .XXX ± .010, .XX ± .03, .X ± .1
ANGLES ± 1/2°
MACHINED SURFACES $\sqrt{}$ EXCEPT AS NOTED (PER MIL STD 10)

DRAWN D. CLEVELAND 1/9/70
CHECKED
STRESS
WEIGHTS
GROUP ENG. [signature] 1/9/70
PROJECT C V [signature] 1/12/70
CUSTOMER

BELL HELICOPTER COMPANY

TITLE COLLAR - BEARING RETAINING, TAIL ROTOR DRIVE

DWG SIZE D | CODE IDENT NO. 97499 | DWG NO. 206-040-350

SCALE FULL & NOTED | SHEET 1 OF 1

D 1-23-70

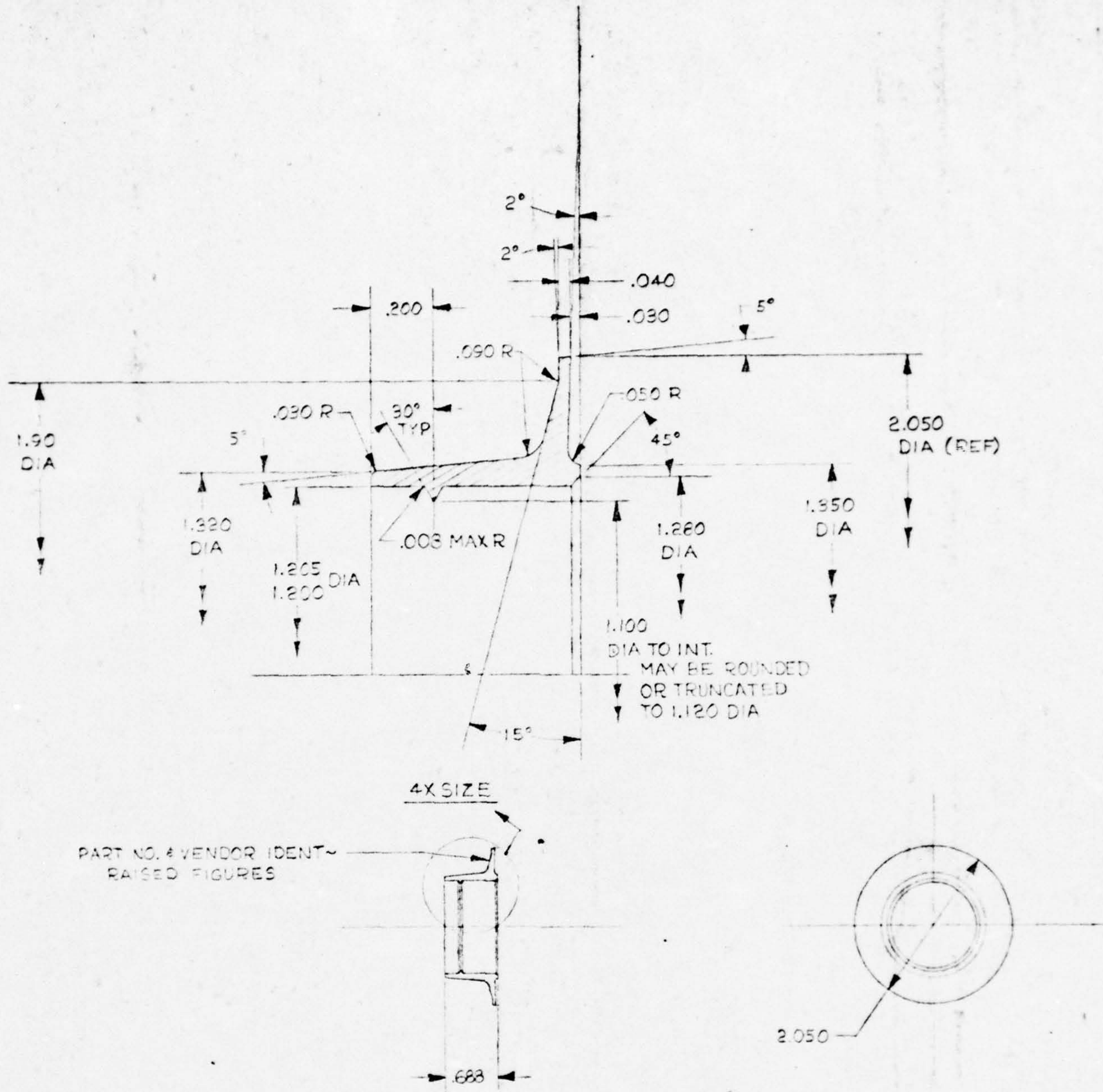

2°
2°
.040
.030
.200
5°
.090 R
.030 R
30° TYP
.050 R
45°
2.050 DIA (REF)
1.90 DIA
5°
1.320 DIA
1.205 1.200 DIA
.003 MAX R
1.260 DIA
1.350 DIA
1.100 DIA TO INT.
MAY BE ROUNDED OR TRUNCATED TO 1.120 DIA
15°
4X SIZE
PART NO. & VENDOR IDENT~ RAISED FIGURES
.688
2.050

Figure 8

LTR	DESCRIPTION	DATE	APPROVED

2

3. PART TO BE INJECTION MOLDED OF GENERAL ELECTRIC GLASS FILLED RESIN GFP3-111 OR EQUIVALENT MATL.
2. DIMENSIONS TO BE MET AT 70°F ~ 90°F.
1. INTERNAL SHAPE MAY BE MACHINED.

NOTES:

206-040-349

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	STOCK SIZE	MATERIAL	MATERIAL SPEC
	206-040-349-1	SHIELD	MOLDED	3	

PARTS LIST WO 6171 EWA 206HA 5.4F

DASH NO.	NEXT ASSY.	USED ON
-1	EC 206HA-4	TEST

APPLICATION

HEAT TREAT ~
FINISH SPEC ~
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS: .XXX ± .010, .XX ± .03, .X ± .1
ANGLES ± 1/2°
MACHINED SURFACES 63 EXCEPT AS NOTED (PER MIL STD 10)

CONTRACT NUMBER
DRAWN D. CLEVELAND 7/3/70
CHECKED
STRESS
WEIGHTS
GROUP ENG. F. J. Cabo 7/9/70
DIR
PROJECT C Harvey
CUSTOMER

BELL HELICOPTER COMPANY

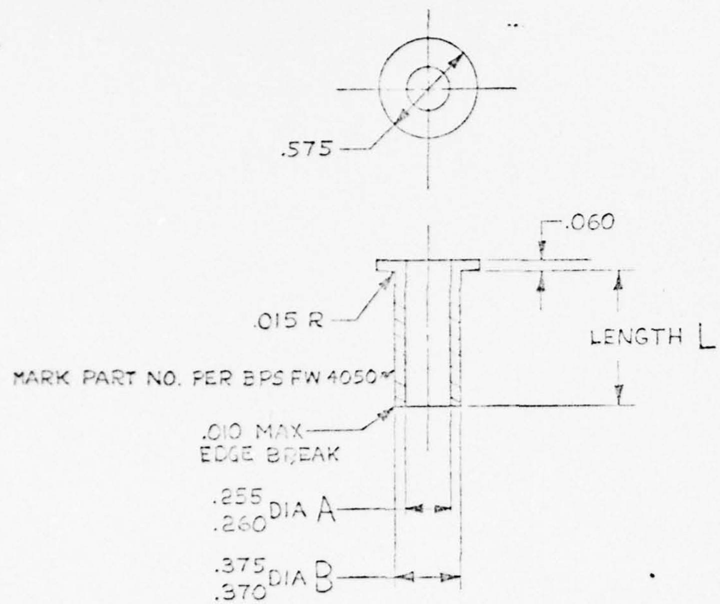
TITLE SHIELD - BEARING, TAIL ROTOR DRIVESHAFT

DWG SIZE D | CODE IDENT NO. 97499 | DWG NO. 206-040-349

SCALE FULL NOTED | SHEET 1 OF 1

I 7-20-70

DASH NO.	-1	-3	-5
DIM. L	.550~.545	.710~.705	.825~.820



3. AS ALT MATL USE STL BAR AMS 6370 5/8 DIA x LENGTH IND.
2. DIA'S A & B TO BE CONCENTRIC WITHIN .005 T.I.R.
1. BREAK EDGES .015 x 45° OR .015 R EXCEPT AS OTHERWISE NOTED.

NOTES:

206-040-351

PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	STOCK SIZE	MATERIAL	MATERIAL SPEC		
206-040-351-5	SPACER	5/8 x .219 WALL x 1.1	4130 TUBE	AMS 6371		CC2
206-040-351-3	SPACER	5/8 x .219 WALL x 1.0	4130 TUBE	AMS 6371		CC2
206-040-351-1	SPACER	5/8 x .219 WALL x .9	4130 TUBE	AMS 6371		CC2

PARTS LIST W.O. 6171 EWA 206 HA 3 & 5

BPS FW 4140
206-947-002

D. CLEVELAND

63√

BELL HELICOPTER COMPANY

SPACER-
SHOULDERED,
BEARING HANGER

C 97499 206-040-351

Figure 9

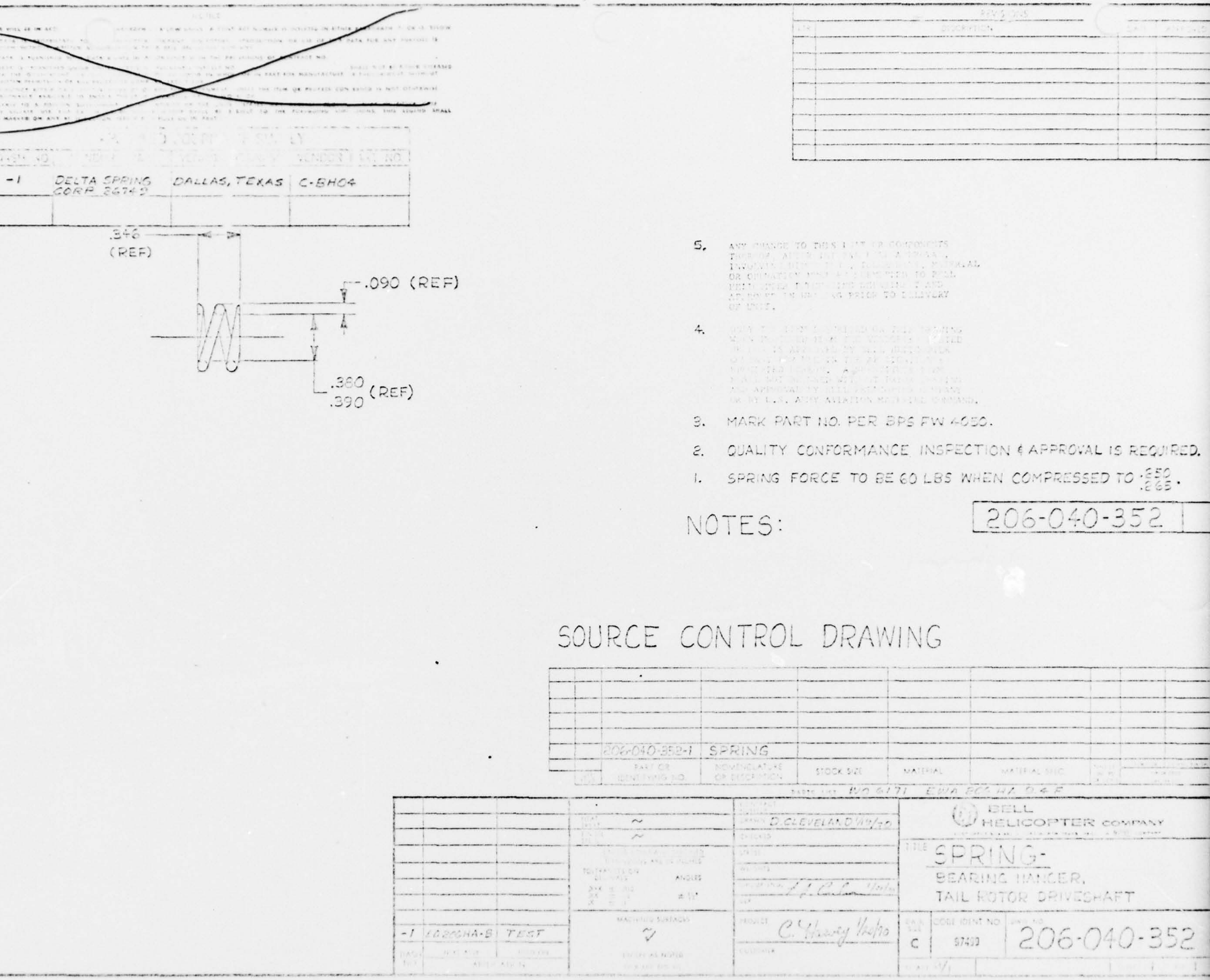

-1
DELTA SPRING CORP 24742
DALLAS, TEXAS
C-BH04
.346 (REF)
.090 (REF)
.380
.390 (REF)
5.
4.
3. MARK PART NO. PER BPS FW 4050.
2. QUALITY CONFORMANCE INSPECTION & APPROVAL IS REQUIRED.
1. SPRING FORCE TO BE 60 LBS WHEN COMPRESSED TO .250/.265.
NOTES:
206-040-352
SOURCE CONTROL DRAWING
206-040-352-1
SPRING
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
STOCK SIZE
MATERIAL
MATERIAL SPEC
D. CLEVELAND
BELL HELICOPTER COMPANY
SPRING-
BEARING HANGER,
TAIL ROTOR DRIVESHAFT
C
97499
206-040-352
-1
TEST

Figure 10

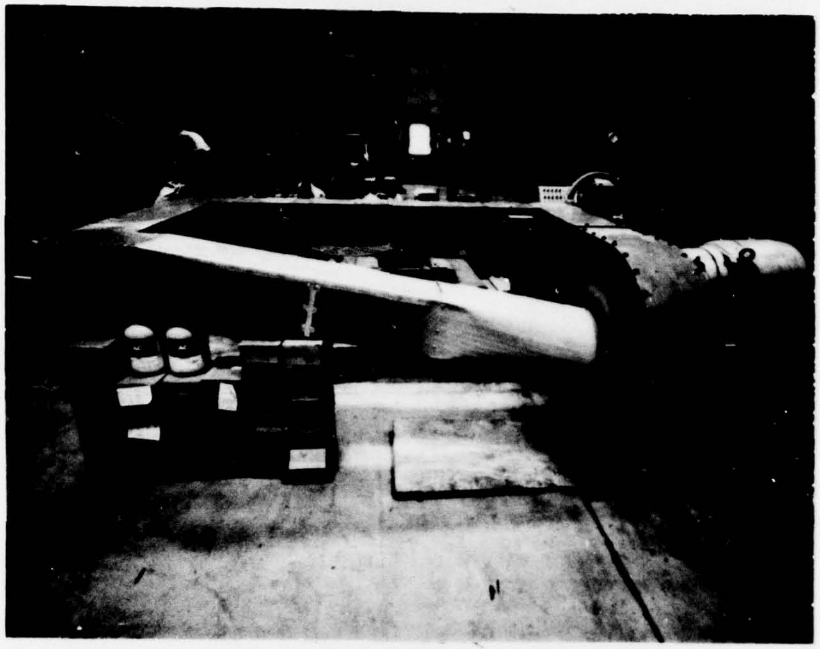


Figure 11

Test stand showing 30" centrifugal blower and supply of test dust.

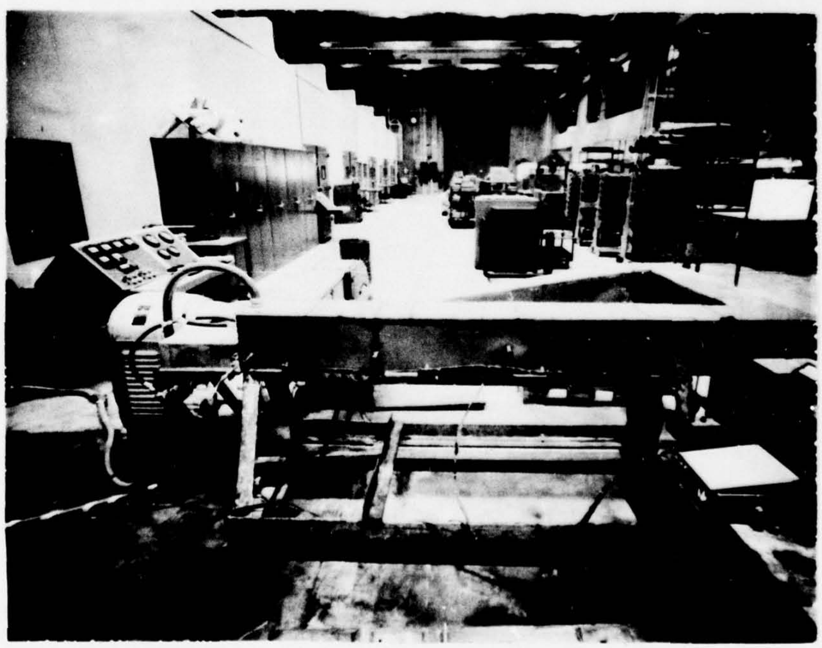


Figure 12

Details of the drive motor for the test shafts and thermocouple wire installations.

The adapter shown in Figure 13 was used to measure the breakaway torque of a bearing mounted in the modified hanger (Fig. 14), and compared to the breakaway torque of a bearing mounted in the production 206-040-344-1 hanger assembly. Both configurations were evaluated at four temperature levels to determine the influence of differential expansion between the aluminum hanger and steel bearing on the retention of the bearing outer ring.

Assembly

Production bearing assemblies were built up per standard assembly techniques. The initial proposed assembly technique for the modified bearing assemblies incorporating the 206-040-350-1 collar (Fig. 7) and the 206-040-349-1 shield (Fig. 8) was to position the collar on the tail rotor drive shaft, then install the 206-040-339-3 bearing (Fig. 4) on the collar and then snap the shields up to both sides of the bearing. It was found that the blueprint configuration of the 206-040-349-1 shield and the 206-040-350-1 collar could not be assembled together after the collar was installed on the tail rotor drive shaft because of excessive interference.

The locking rings on both the 206-040-349-1 shield and the 206-040-350-1 collar were relieved by increasing the inside diameter of the shield locking ring from 1.100 diameter to 1.156 diameter and decreasing the outside diameter of the collar locking rings from 1.185/1.175 diameter to 1.175/1.168 diameter. These changes were made in an attempt to allow assembly by the initial proposed assembly technique described above. It was found that the shield and collar so modified could not be assembled together after the collar had been installed on the tail rotor drive shaft.

The next attempt was to assemble the EXP 18426A-5G bearing, the 206-040-350-1 collar with relieved locking rings, and the 206-040-349-1 shields with relieved locking rings together as a subassembly and then install the subassembly onto the tail rotor drive shaft with the aid of a light film of petroleum jelly. This method of assembly allowed the subassemblies to be installed on the tail rotor drive shaft. However, the tail rotor drive shaft on which all four hangers were installed by this method slipped through the hanger assemblies upon initial runup far enough to disengage the drive spline and cease rotation. It was found that bearing assemblies installed in subassemblies by this method could be retained in position for test purposes by sliding the bearing assembly onto the tail rotor drive shaft with the aid of a light film of petroleum jelly and then sliding the bearing assembly back and forth past the running position, wiping away the lubricant residue after each pass until virtually all the lubricant was removed. However, installation of the subassembly onto the tail rotor drive shaft without the aid of a lubricant could not be affected.

Finally, an attempt was made to assemble a 206-040-349-1 shield with 1.156 inside diameter locking ring modified as shown in

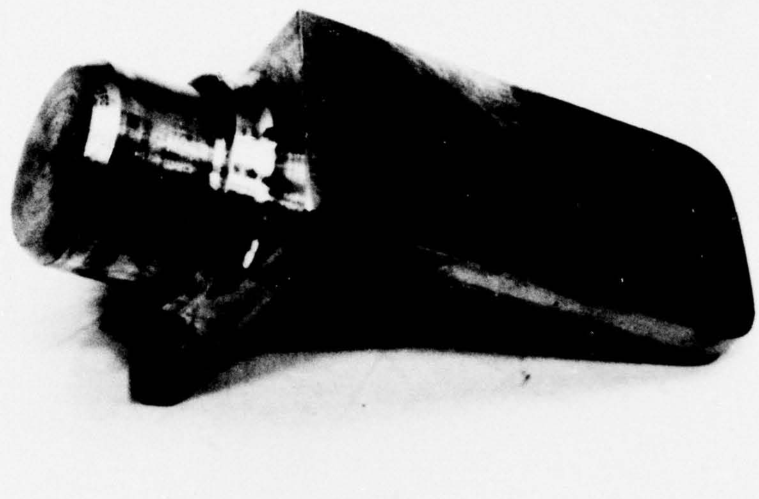


Figure 13. Breakaway Torque Measuring Adapter

Figure 14. Torque Being Applied in Horizontal Plane

Figure 15 onto a 206-040-350-1 collar modified to a locking ring diameter of 1.175/1.168 while the collar was installed on the tail rotor drive shaft. It was found that this combination could be assembled provided that considerable patience was used in the assembly. However, two bearings assembled by this method, running in positions 1 and 2 had the shields back away from the bearing approximately 1/16" on both sides of the bearing after approximately 5 hours of run time.

Subsequent experimentation with assembly and disassembly techniques resulted in a successful combination using the 206-040-349-1 shield modified as shown in Figure 15 and the 206-040-350-1 collar modified to a locking ring diameter of 1.175/1.168 by prepositioning the -350 collar on the shaft then bonding the collar in place, using Silastic RTV bonding compound.

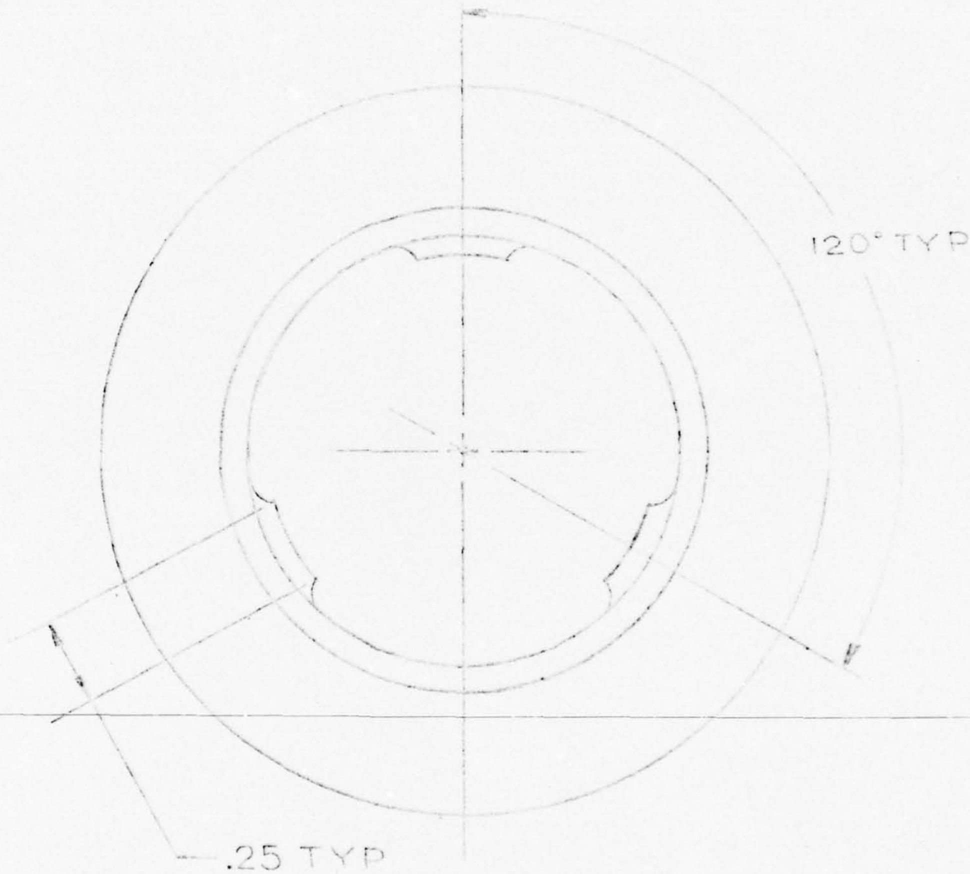


Figure 15. 206-040-349 Collar Final Configuration

RESULTS

The affect of air velocity on the life of shielded bearings is demonstrated in Figure 16. There is an apparent peak affect at approximately 40 miles per hour, where eleven (11) failures occurred (locations 5 and 6). The influence of air velocity predominates over bearing load as evidenced by the load distribution shown in Table 1. Locations 5 and 6 are subjected to lower loads than locations 3 and 4, and yet 5 and 6 experienced a higher number of failures. Some variation of the failure distribution in Figure 16 may be expected with a change in load, especially at the higher velocity at locations 7 and 8, where ten (10) failures occurred with no measurable load.

RESULTS OF STATIC TESTING OF SPRING-LOADED BEARING CLAMP-UP FEATURE OF 206HA-5-1

Breakaway torque between the bearing and hanger assembly was measured by the use of a 0 to 300 inch-pound torque wrench and the adapter shown in Figure 13. The 206HA-5-1 hanger assembly was fitted with an EXP 18426-3G bearing whose outer race was covered with a light film of 204-040-755-3 lubricant. Torque was applied in both the vertical and horizontal planes and two readings were taken in each plane at 75, 100, 115, and 125 degrees Fahrenheit. Heating of the hanger assembly was accomplished with a heat lamp and temperature of the assembly was measured externally adjacent to the support bushing boss with a hand-held pyrometer. The average of the four readings at each temperature shown in Table 2 was used to plot the points in Figure 17. Breakaway torques of the 206HA-5-1 hanger assembly and the EXP 18426-3G bearing combinations as noted in Table 2.

The 206-040-344-1 hanger assembly was fitted with a 206-040-339-3 bearing per standard assembly procedures and subjected to identical testing. Breakaway torques of this combination are listed in Table 2.

206-097-005

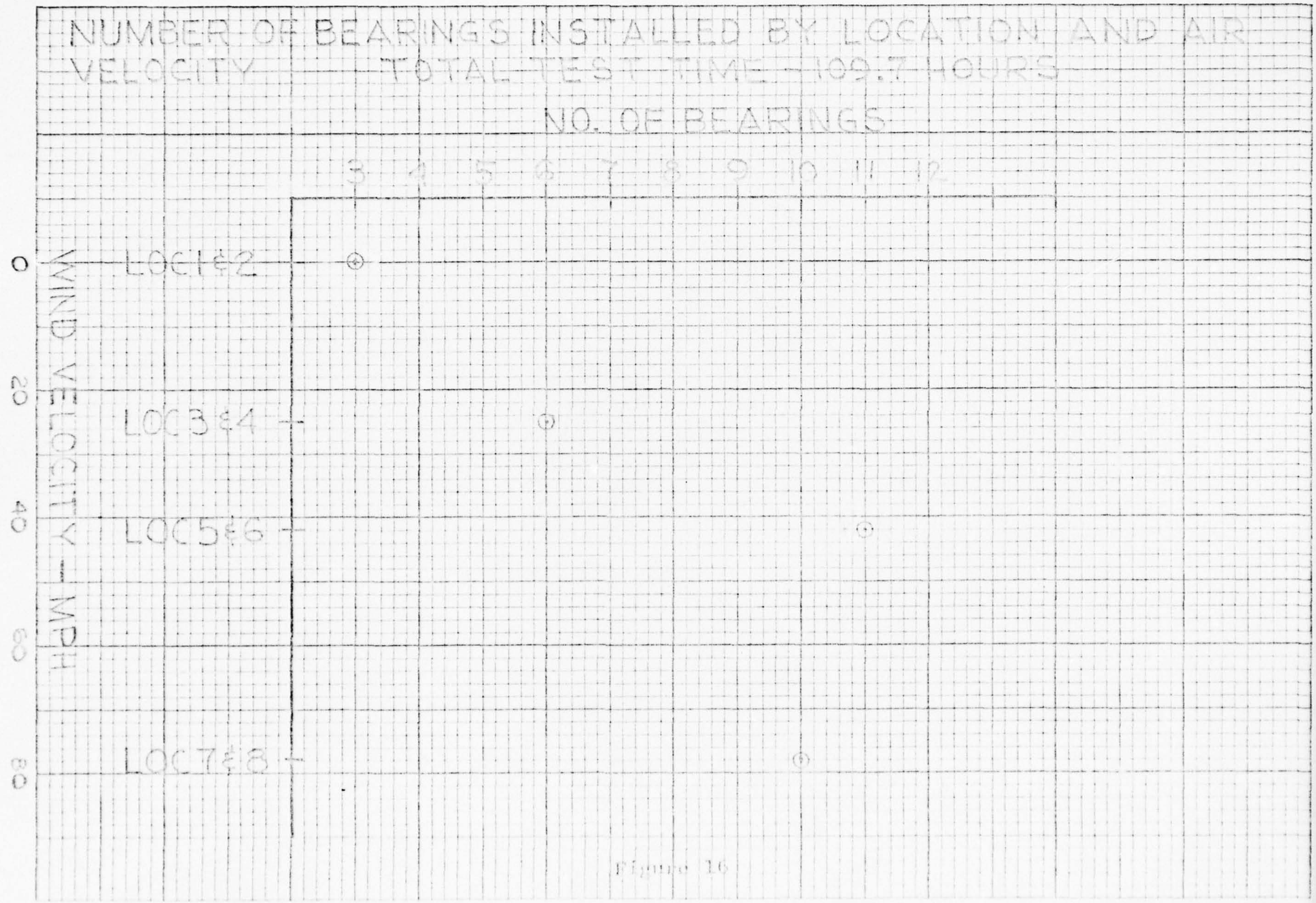


Figure 16

TABLE 1

HANGER BEARING LOADS DUE TO CURVATURE OF INSTALLED SHAFT

1 2 3 4 5 6 Aft

I. Nominal hanger bearing positions OH-58A.

Bearing	Load (Bearing Reaction)
1	3.8 pounds
2	3.8 pounds
3	0
4	3.8 pounds
5	3.8 pounds
6	0

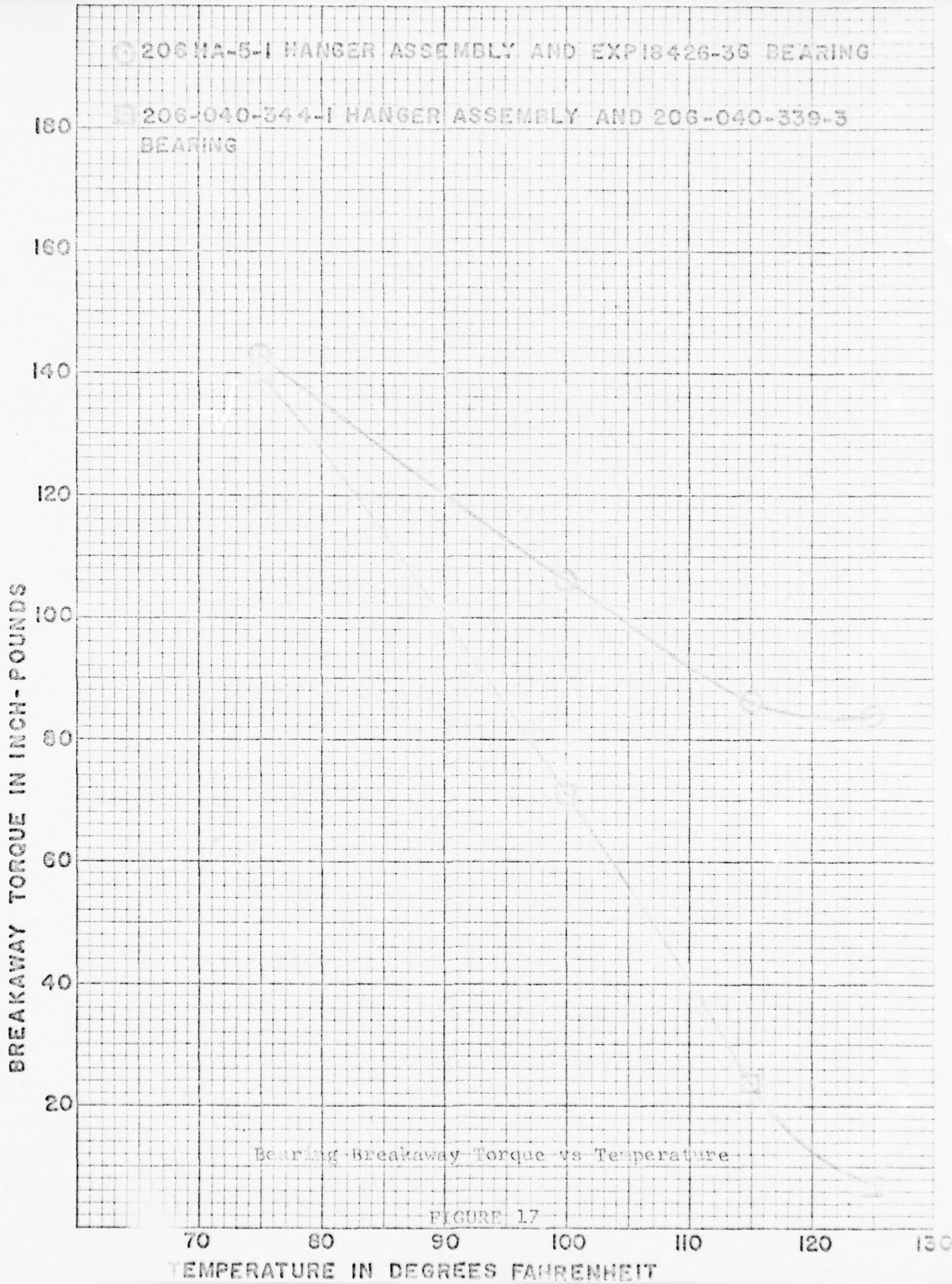
II. Most severe hanger bearing position OH-58A.

Bearing	Load	Location from Nominal
1	.20 pound	.030
2	8.12 pound	.030
3	*16.64 pound	.030
4	8.12 pound	
5	.20 pound	
6		

* Load on bearing #3 = 2 (#1 + #2) assuming the shaft to be cantilevered at #3.

III. Hanger bearing positions in test lab set-up.

Bearing	Load
1-2	7.0 pound
3-4	15.0 pound
5-6	7.0 pound
7-8	0



Bearing Breakaway Torque vs Temperature

FIGURE 17

TABLE 2

BREAKAWAY TORQUE

206HA-5-1 HANGER ASSEMBLY WITH CAD PLATED EXP18426-3G

Temperature, °F

	75°		100°		115°		125°	
	Vert.	Lat.	Vert.	Lat.	Vert.	Lat.	Vert.	Lat.
Torque In.-Lbs	130	175	90	130	85	95	80	95
Torque In.-Lbs	110	155	85	100	75	90	80	85

206-040-344-1 HANGER ASSEMBLY WITH STANDARD -339-3

	75°		100°		115°		125°	
	Vert.	Lat.	Vert.	Lat.	Vert.	Lat.	Vert.	Lat.
Torque In.-Lbs	150	135	80	60	30	20	3	5
Torque In.-Lbs	150	130	80	65	25	20	5	15

TABLE 3

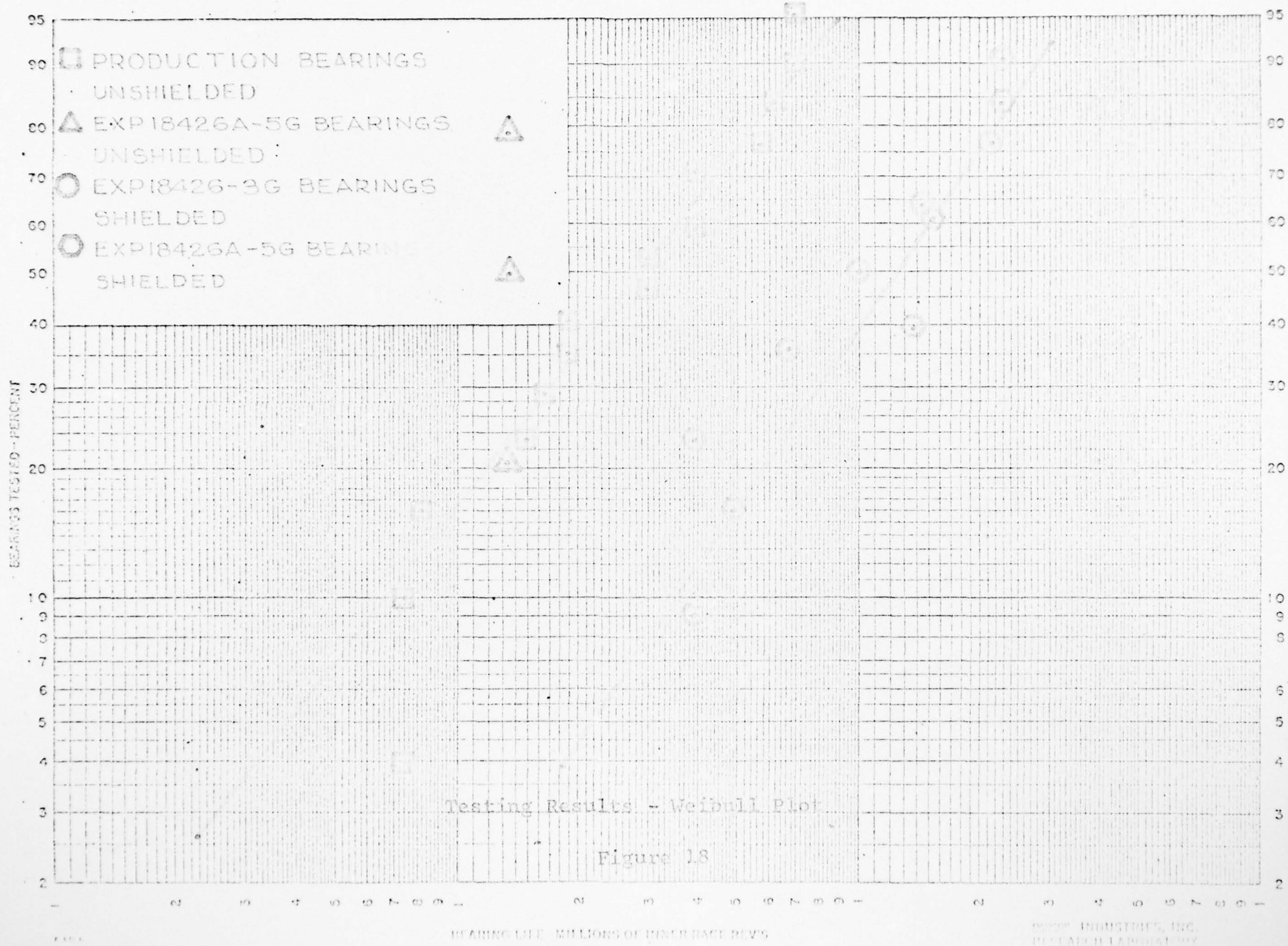
ANALYSIS OF TESTING RESULTS

The following data is derived from Figure 18, a Weibull plot of the data presented in Table 4.

B_{10} Hours	B_{50} Hours	e	
1.96	8.48	1.23	Test Configuration 1
3.98	3.98	0	Test Configuration 2
7.70	32.16	1.35	Test Configuration 3
11.11	39.47	1.86	Test Configuration 4

However, greater confidence exists in the set grouping 1 and 2 versus 3 and 4 (with and without shields) than the grouping 1 and 3 versus 2 and 4 (seal I.D. change). Therefore, for shield evaluation alone the results are:

B_{10} Hours	B_{50} Hours	e	
1.96	8.48	1.23	Test Configurations 1 and 2 (no shields)
10.23	36.55	1.47	Test Configurations 3 and 4 (with shields)



Testing Results - Weibull Plot

Figure 18

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TABLE 4 - TESTING RESULTS

Bearing Test Serial Number	Test Time at Removal (Hours)	Position in Test Machine	Run Time on Bearing (Hours)	Bearing Assembly Configuration *	Remarks
TRL-3	11.6	5	11.6	1	Bearing very rough. Figs. 15 and 16.
TRL-4	11.6	7	11.6	1	Bearing siezed and cut collar into pieces. Bearing outer race spun in hanger. Figs. 17-20.
TRL-5	11.6	8	11.6	1	Bearing siezed and cut collar into halves. Figs. 21-24.
TRL-6	18.0	6	18.0	1	Bearing siezed and spun on collar. Figs. 25 and 26.
TRL-7	20.4	4	20.4	1	Bearing very rough. Fig. 27.
TRL-8	20.4	6	2.4	1	Bearing siezed and spun on collar. Bearing outer race spun in hanger. Figs. 28 and 29.
TRL-9	20.4	8	8.8	1	Bearing very rough - full of dust - excessive internal clearance. Bearing outer race spun in hanger. Fig. 30.
TRL-10	20.4	2	20.4	1	Bearing very rough. Fig. 31.
TRL-11	24.8	6	4.8	1	Bearing siezed and spun on collar. Figs. 32 and 33.
TRL-12	29.2	6	4.4	1	Bearing completely destroyed itself. Outer race spun in hanger. Fig. 34.

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TABLE 4 - TESTING RESULTS (continued)

Bearing Test Serial Number	Test Time at Removal (Hours)	Position in Test Machine	Run Time on Bearing (Hours)	Bearing Assembly Configuration *	Remarks
TRL 13	29.2	8	8.8	1	Bearing siezed and spun on collar. Fig. 35.
TRL 15	31.4	6	12.2	1	Bearing siezed and spun on collar. Outer race spun in hanger. Figs. 40-42.
TRL-17	31.4	8	2.2	1	Bearing siezed and spun on collar. Outer race spun in hanger. Figs. 44-46.
TRL-19	37.0	4	16.6	1	Bearing siezed and spun on collar. Figs. 47-49.
TRL-20	37.0	6	5.6	1	Bearing internal clearance excessive. No grease left at all. Fig. 50.
TRL-21	37.0	8	5.6	1	Bearing very rough. Full of dust. Fig. 51.
TRL-23	41.0	4	4.0	2	Bearing very rough. Fig. 55.
TRL-24	41.0	6	4.0	2	Bearing siezed and spun on collar. Figs. 56-58.
TRL-25	41.0	8	4.0	2	Bearing siezed and spun on collar. Fig. 59.
TRL-14	31.4	5	19.8	3	Bearing siezed and spun on collar. Figs. 36-39.
TRL-16	31.4	7	19.8	3	Bearing very rough. Fig. 43.

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TABLE 4 - TESTING RESULTS (continued)

Bearing Test Serial Number	Test Time at Removal (Hours)	Position in Test Machine	Run Time on Bearing (Hours)	Bearing Assembly Configuration *	Remarks
TRL-22	41.0	3	29.4	3	Bearing siezed and spun on collar. Figs. 52-54.
TRL-26	52.0	7	11.0	3	Bearing very rough and cage just cracked. Fig. 60.
TRL-31	84.8	5	42.5	3	Bearing siezed and cut coller in two pieces, then severed shaft. Figs. 64-65.
TRL-40	106.7	3	64.4	3	Bearing siezed and cut collar in two. Figs. 68-70.
TRL-38	109.7	1	67.4	3	Bearing very smooth at removal for end of testing. Figs. 71-72.
TRL-27	56.8	8	14.5	4	Bearing very rough. Remaining grease hard and dry. Cage cracked. Fig. 61.
TRL-30	83.0	6	40.7	4	Cage blue but not cracked. Excessive internal clearance. Spun on collar. Figs. 62-63.
TRL-33	87.8	4	45.5	4	Bearing siezed and spun on collar. Figs. 66-67.
TRL-39	109.7	2	67.4	4	Bearing very smooth at removal end of test. Figs. 73-74.

* 1. Production 206-040-339-3 bearing, 206-040-315-1 collar. 206-040-344-1 hanger assembly.
2. EXP18426A-5G bearing, 206-040-315-1 collar, 206-040-344-1 hanger assembly.
3. EXP18426-3G bearing, 206-040-350-1 collar, 206-040-349-1 shields, 206HA-5 hanger assy.
4. EXP1826A-5G bearing, 206-040-350-1 collar, 206-040-349-1 shields, 206HA-5 hanger assy.

CONCLUSIONS

1. Petroleum jelly or similar lubricants cannot safely be used to ease installation of bearing assemblies onto the tail rotor drive shaft.

2. All configurations evaluated in this test incorporating the 206-040-349-1 shield and the 206-040-350-1 collar proved very difficult to assemble unless the -350-1 collar was bonded to the shaft.

3. Under the severe conditions of this test the EXP 18426A-5G bearing mounted on the 206-040-350-1 collar with 206-040-349-1 shields exhibited a B_{10} life on the order of five times greater than the production 206-040-339-3 bearing mounted on the 206-040-315-1 collar. A substantially greater resistance to particle intrusion was demonstrated, Fig. 18.

4. Test results show the proposed spring-loaded clamping feature (E.O. 206HA-5) for the 206-040-344-1 hanger assembly produces positive bearing retention over a wide temperature range.

5. Final design configuration for production incorporation consists of bonding the 206-040-350-1 collar (modified to a locking ring diameter of 1.175/1.168) to the shaft and installing the 206-040-349-1 shield modified to a locking ring diameter of 1.156 inches on either side of the 206-040-339 bearing.

APPENDIX "A"

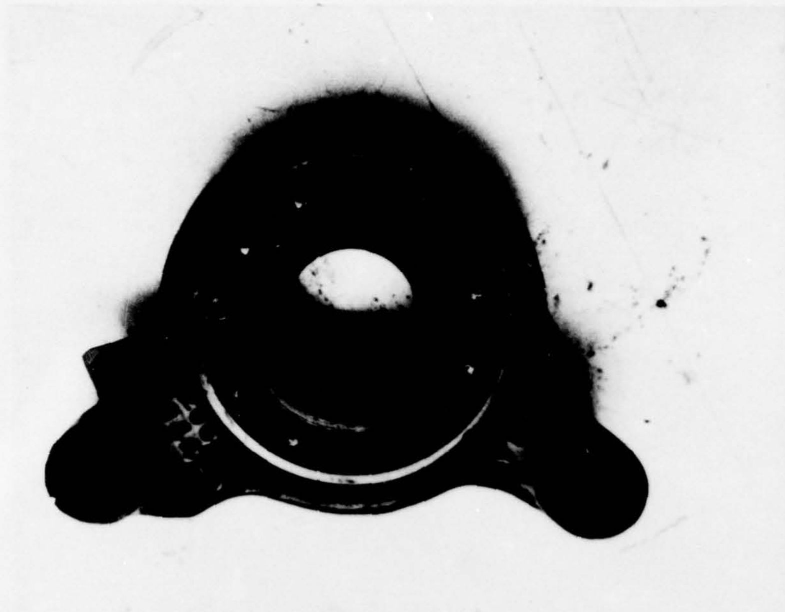

Figure 19. Bearing S/N TRL-3. Removed Position 5 With 11.6 Hours Time. Shown With Seal Removed.

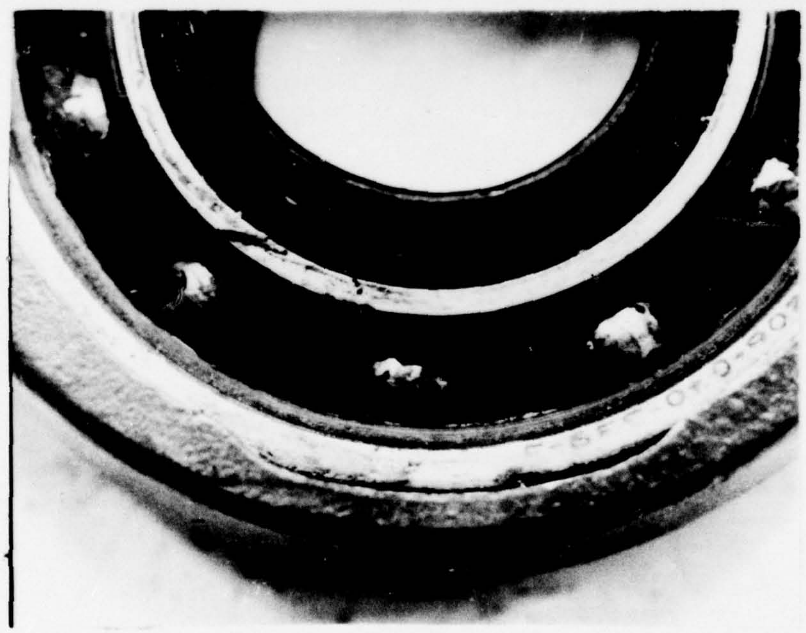

Figure 20. Bearing S/N TRL-3. 2.5x Enlarged View.

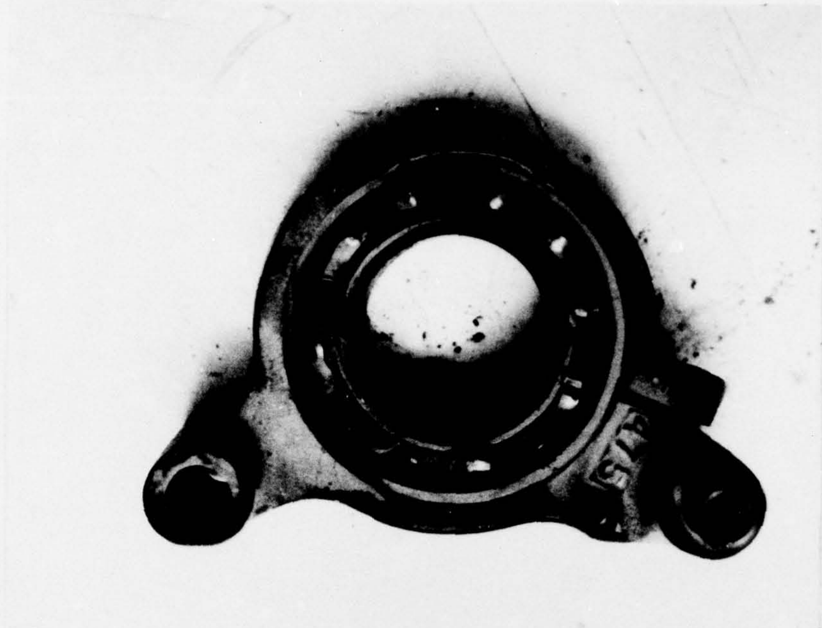

Figure 21. Bearing S/N TRL-4. Removed Position 7 With 11.6 Hours Time. Shown With Seal Removed.

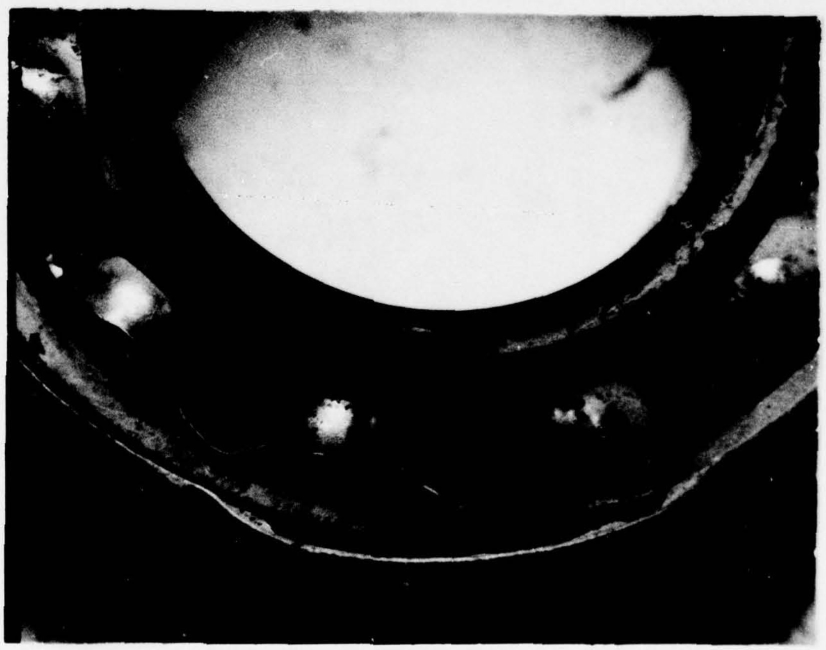

Figure 22. Bearing S/N TRL-4. 3x Enlarged View.

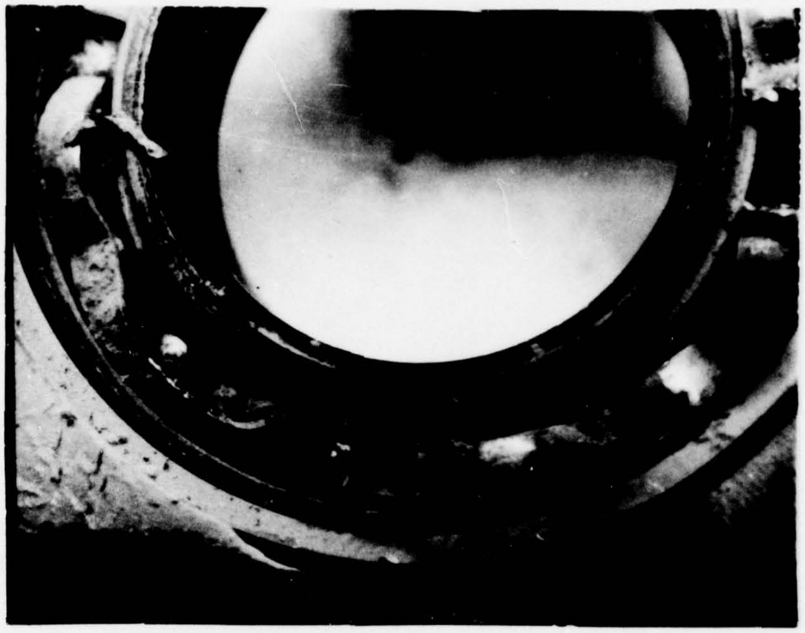

Figure 23. Bearing S/N TRL-4.
2.5x Enlarged View.

Figure 24. 206-040-315-1 Collar From Bearing S/N TRL-4 (Left) Next to a New 206-040-315-1 Collar.

Figure 25. Bearing S/N TRL-5. Removed Position 8 With 11.6 Hours Time. Shown With Seal Removed.

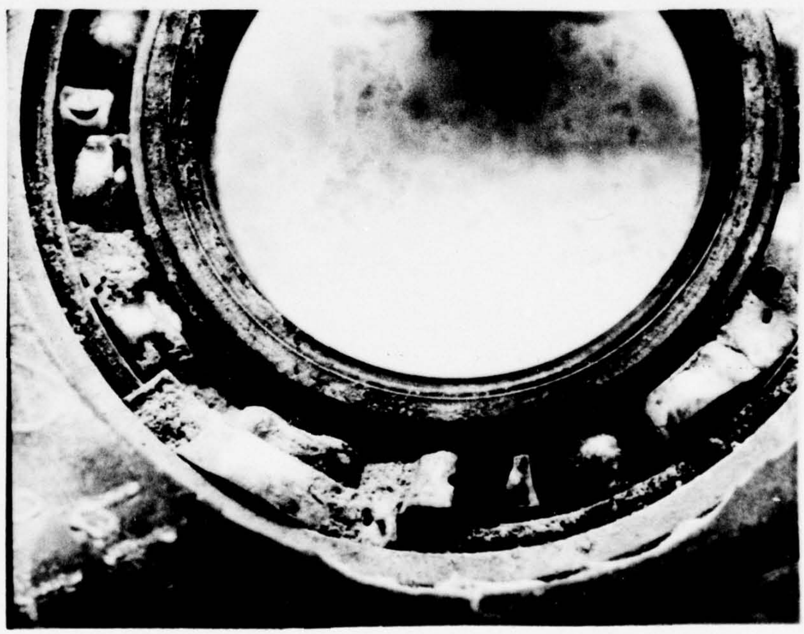

Figure 26. Bearing S/N TRL-5. 2.5x Enlarged View.

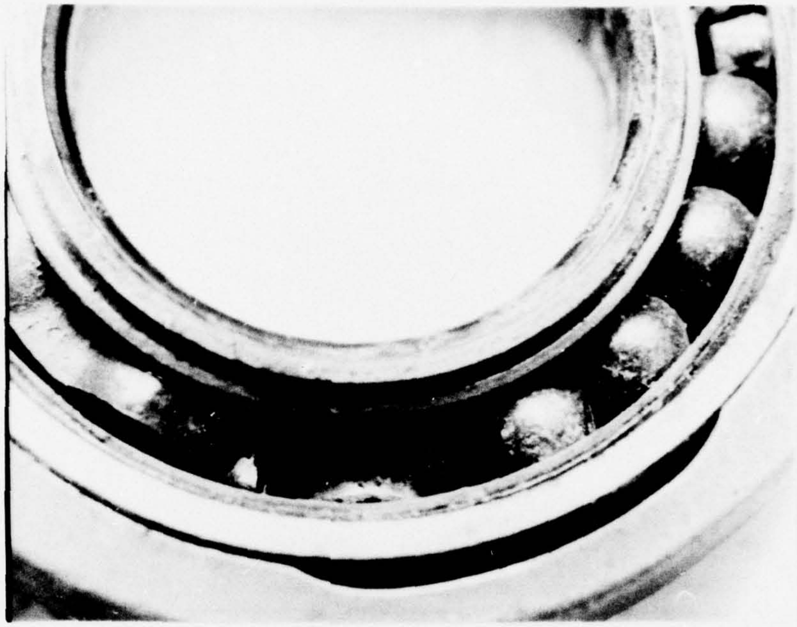

Figure 27. Bearing S/N TRL-5.
2.5x Enlarged View.

Figure 28. 206-040-315-1 Collar From
Bearing S/N TRL-5.

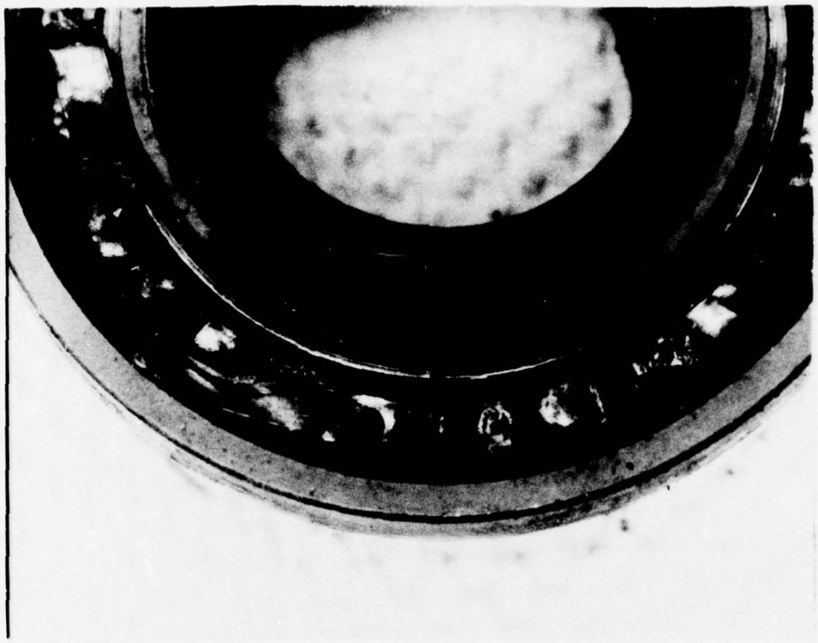

Figure 29. Bearing S/N TRL-6. Removed Position 6 With 18.0 Hours Time. 2.5x Enlarged View.

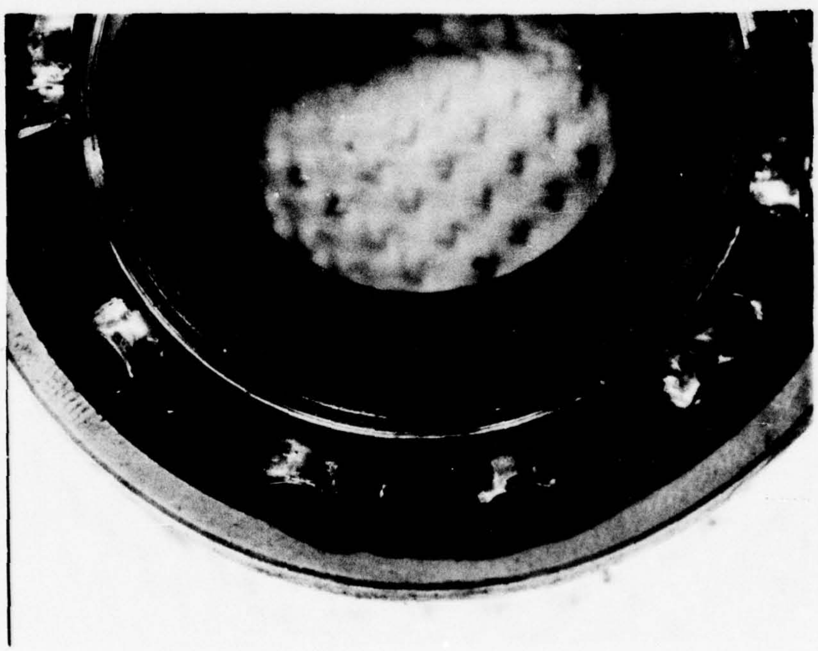

Figure 30. Bearing S/N TRL-6. 2.5x Enlarged View.

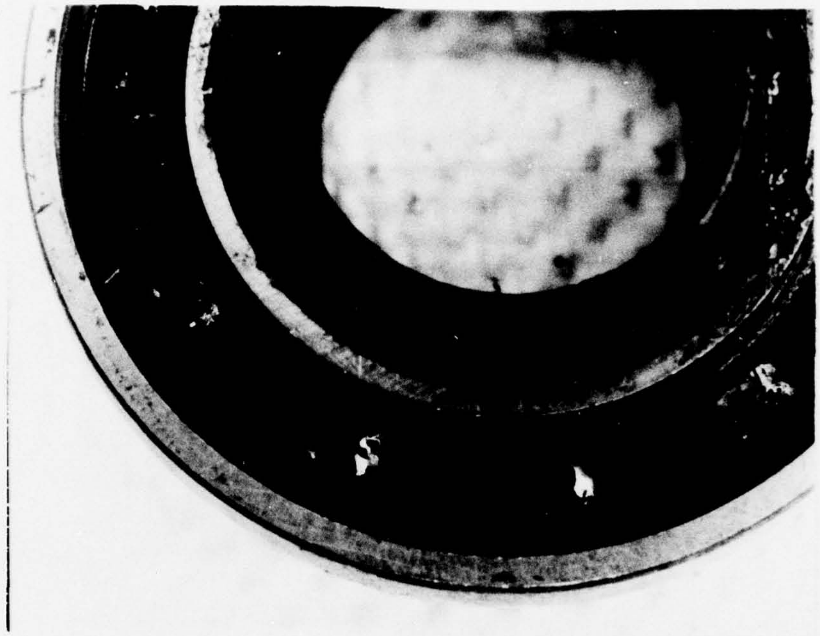

Figure 31. Bearing S/N TRL-7. Removed Position 4 With 20.4 Hours. 2.5x Enlarged View.

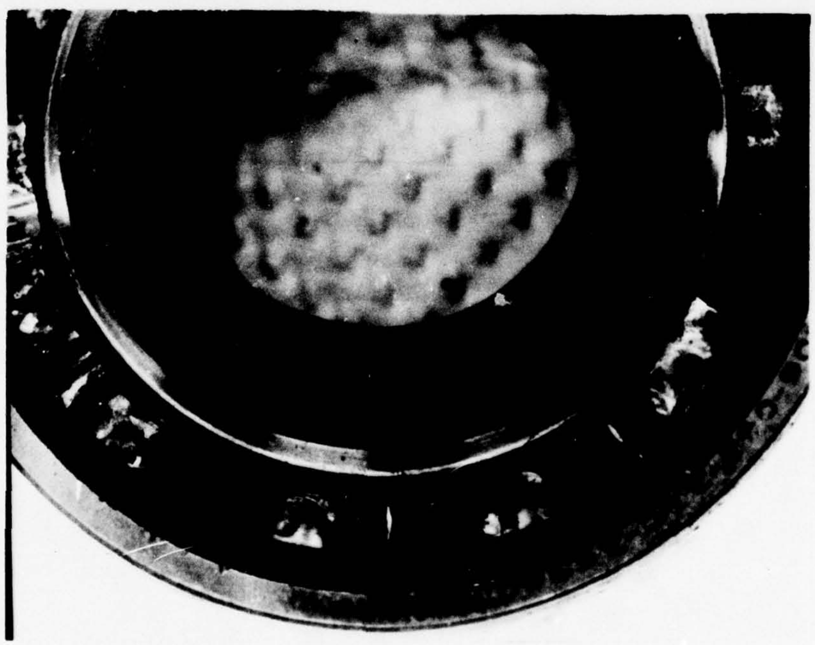

Figure 32. Bearing S/N TRL-8. Removed Position 6 With 2.4 Hours Time. 2.5x Enlarged View.

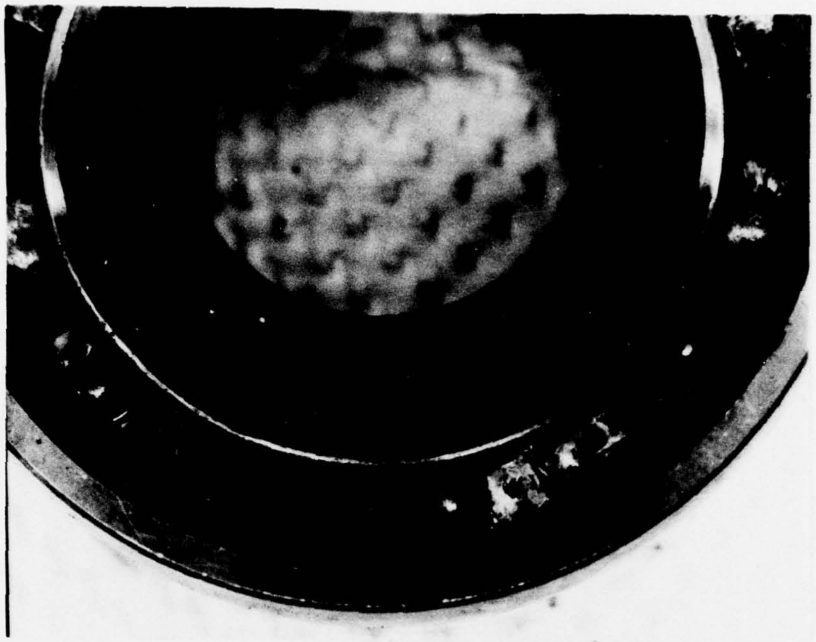

Figure 33. Bearing S/N TRL-8.
2.5x Enlarged View.

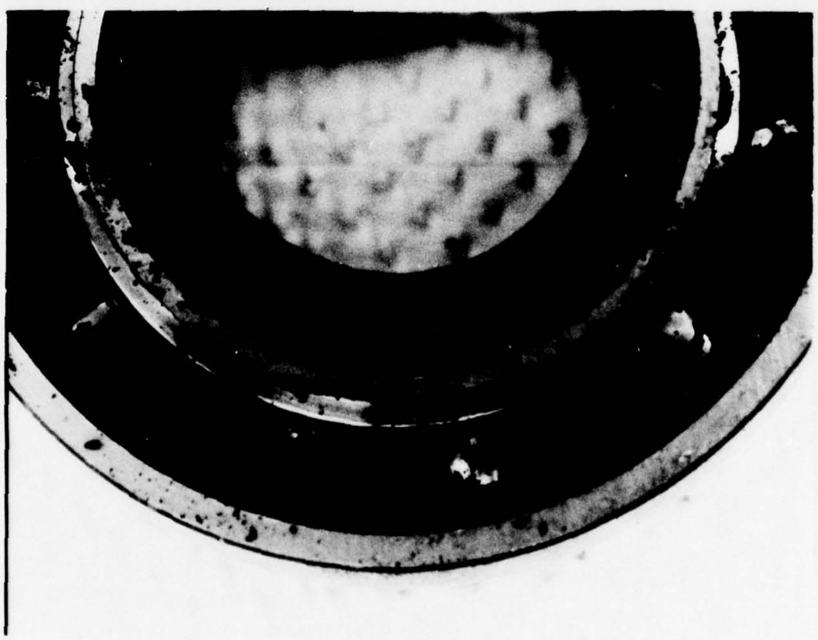

Figure 34. Bearing S/N TRL-9. Removed Position 8
With 8.8 Hours Time. 2.5x Enlarged View.

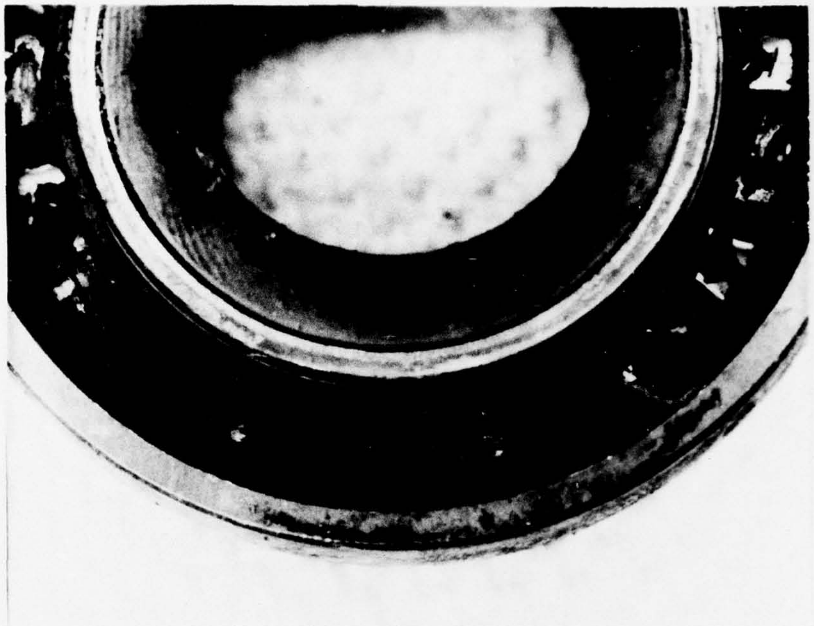

Figure 35. Bearing S/N TRL-10. Removed Position 2 With 20.4 Hours Time. 2.5x Enlarged View.

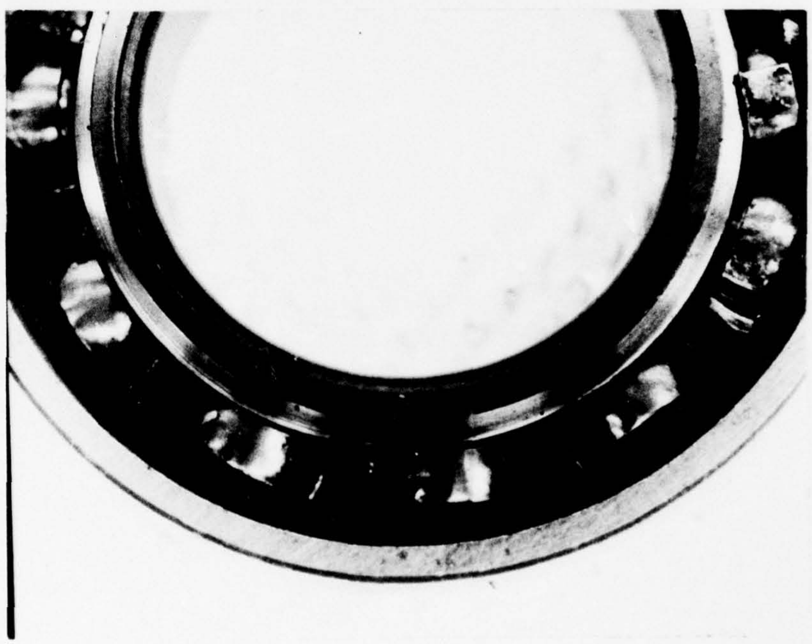

Figure 36. Bearing S/N TRL-11. Removed Position 6 With 4.8 Hours Time. 2.5x Enlarged View.

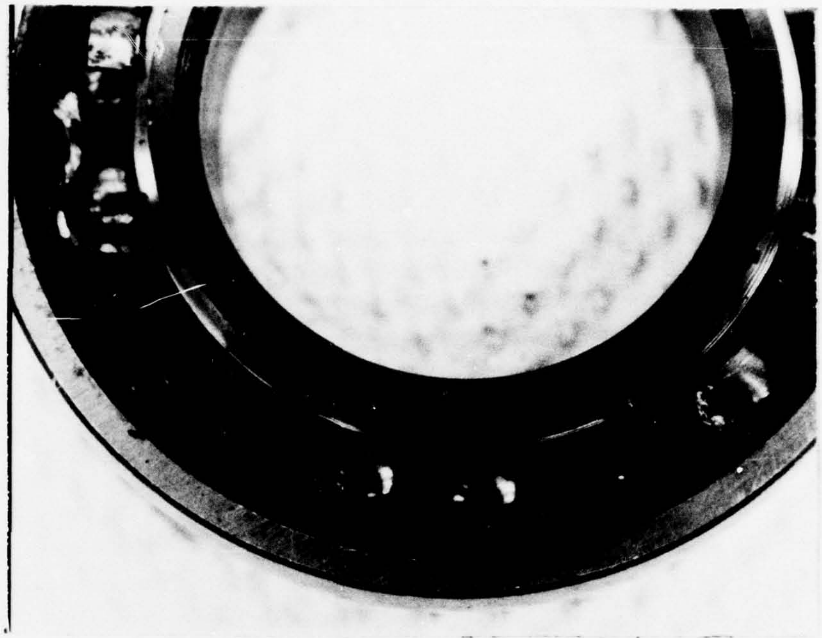

Figure 37. Bearing S/N TRL-11.
2.5x Enlarged View.

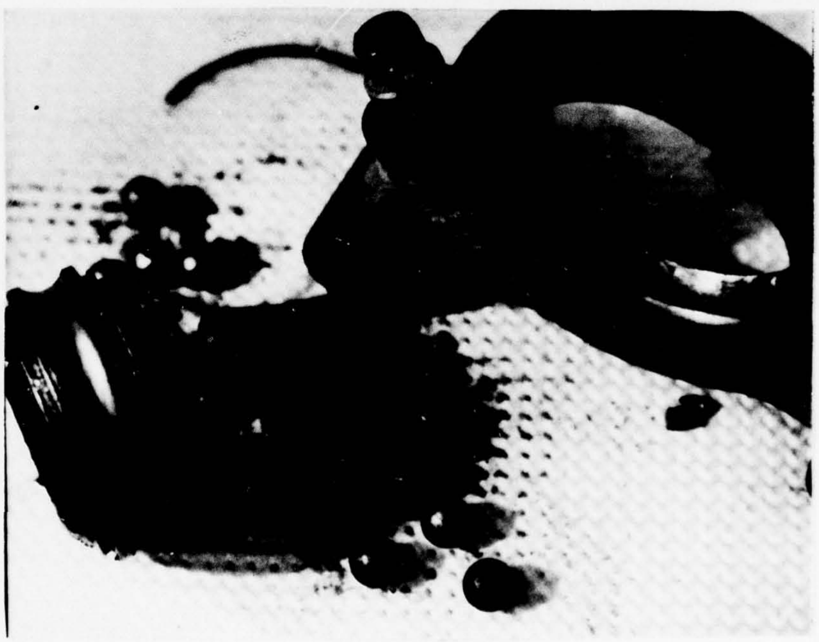

Figure 38. Bearing S/N TRL-12. Removed Position 6 With 4.4 Hours Time. View of Bearing as Removed From Tester.

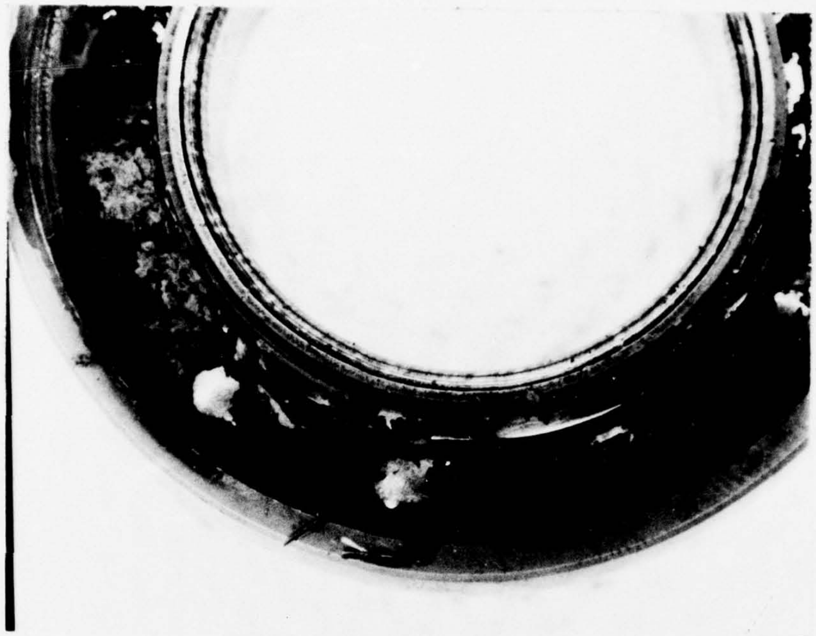

Figure 39. Bearing S/N TRL-13. Removed Position 8 With 8.8 Hours Time. 2.5x Enlarged View.

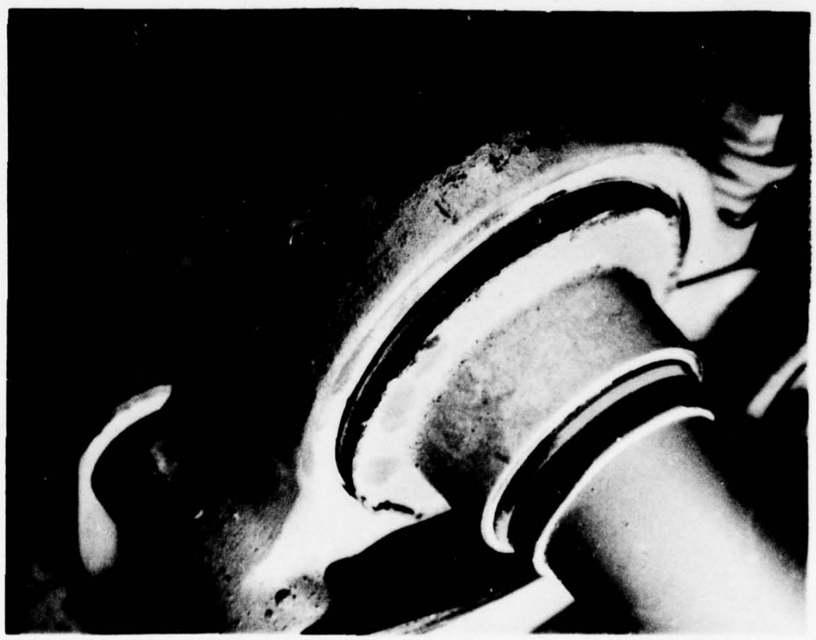

Figure 40. Bearing S/N TRL-14. Removed Position 5 With 19.8 Hours. Shown in Tester Prior to Removal.

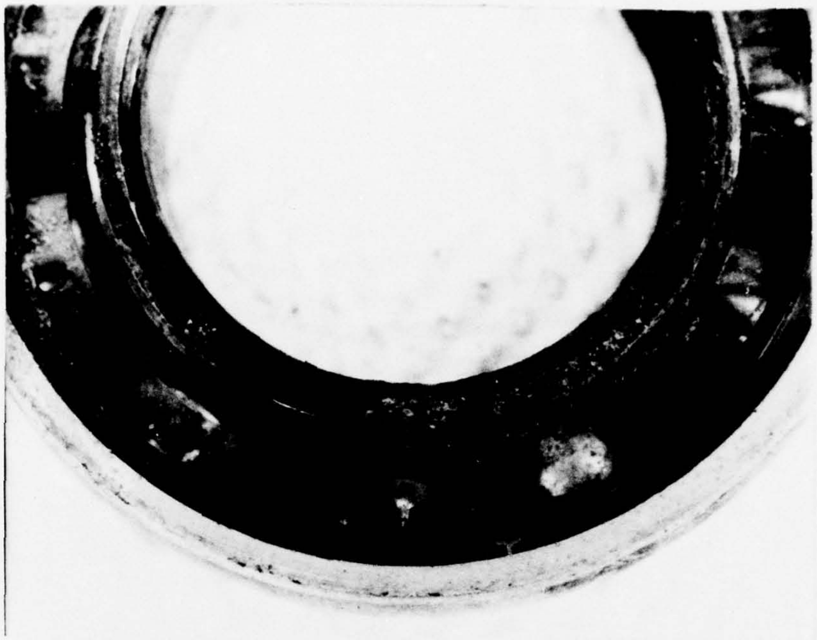

Figure 41. Bearing S/N TRL-14.
2.5x Enlarged View.

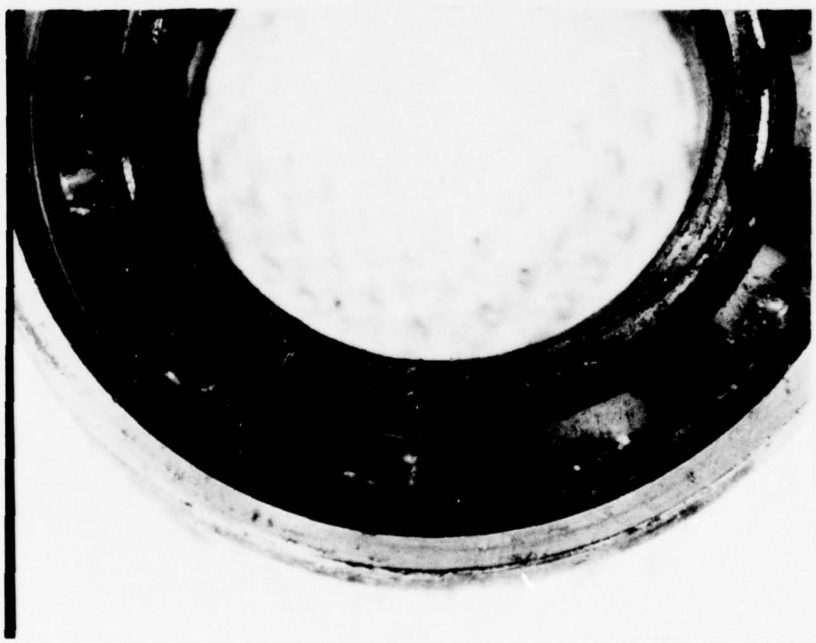

Figure 42. Bearing S/N TRL-14.
2.5x Enlarged View.

Figure 43. 2x Enlarged View of 206-040-350-1
Removed From Bearing TRL-14.

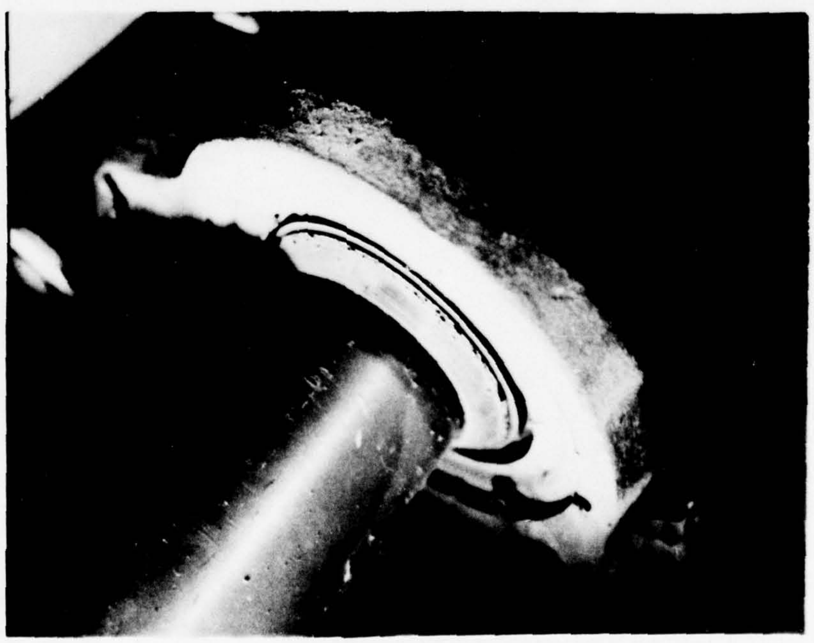

Figure 44. Bearing S/N TRL-15. Removed Position 6
With 12.2 Hours Time. Shown Prior to
Removal From Tester.

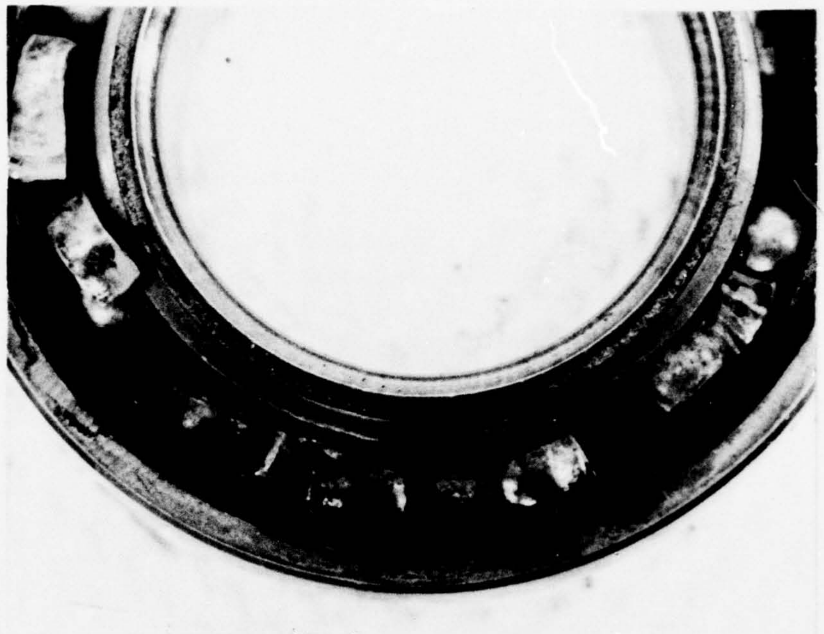

Figure 45. Bearing S/N TRL-15.
2.5x Enlarged View.

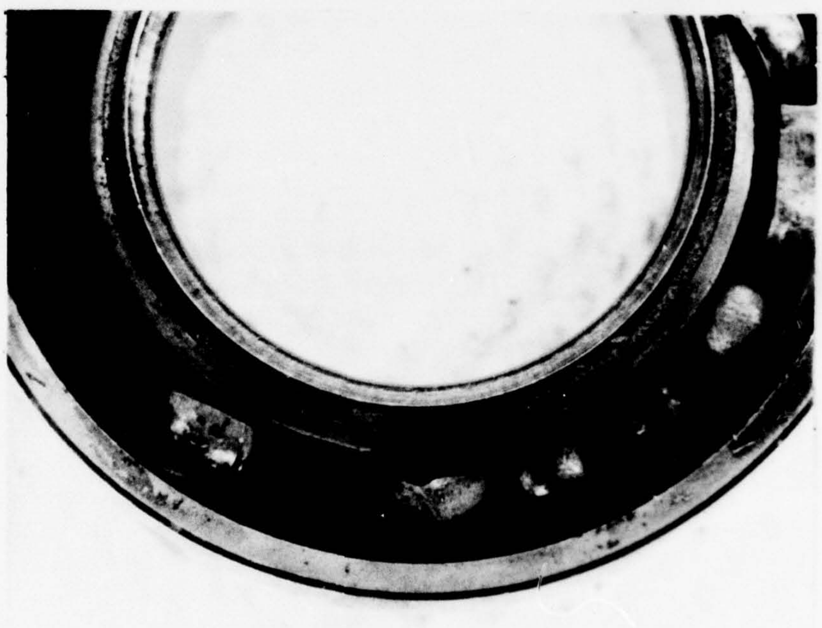

Figure 46. Bearing S/N TRL-15.
2.5x Enlarged View.

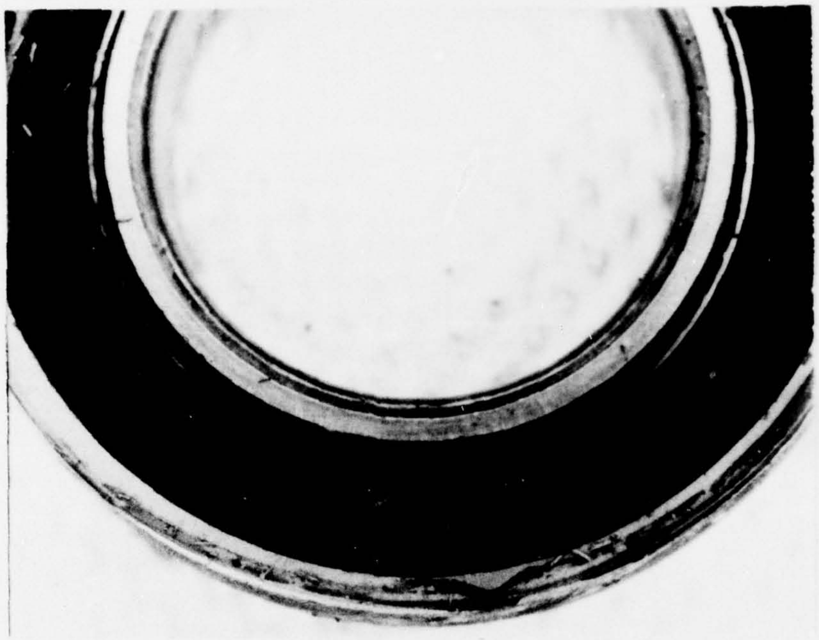

Figure 47. Bearing S/N TRL-16. Removed Position 7 With 19.8 Hours Time. 2.5x Enlarged View.

Figure 48. Bearing S/N TRL-17. Removed Position 8 With 2.2 Hours Time. Shown Prior to Removal From Tester.

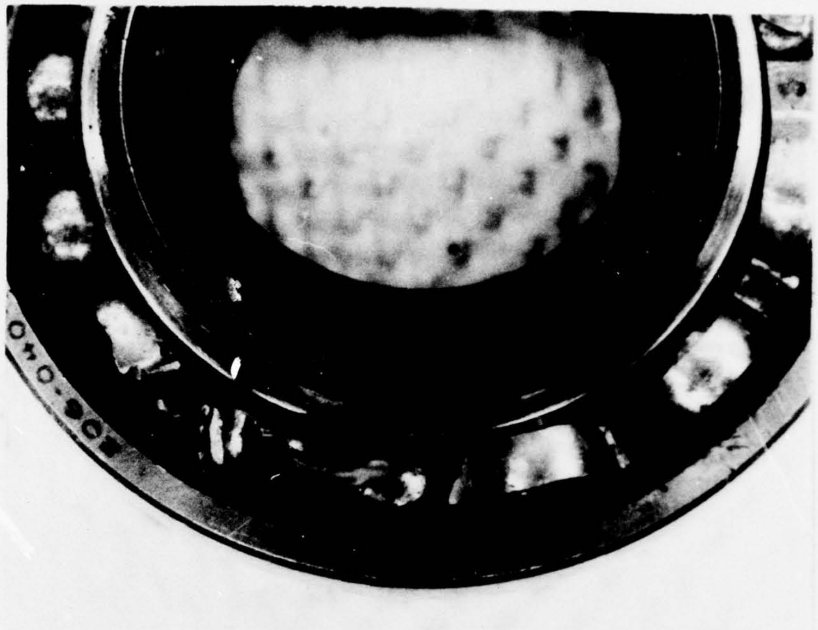

Figure 49. Bearing S/N TRL-17.
2.5x Enlarged View.

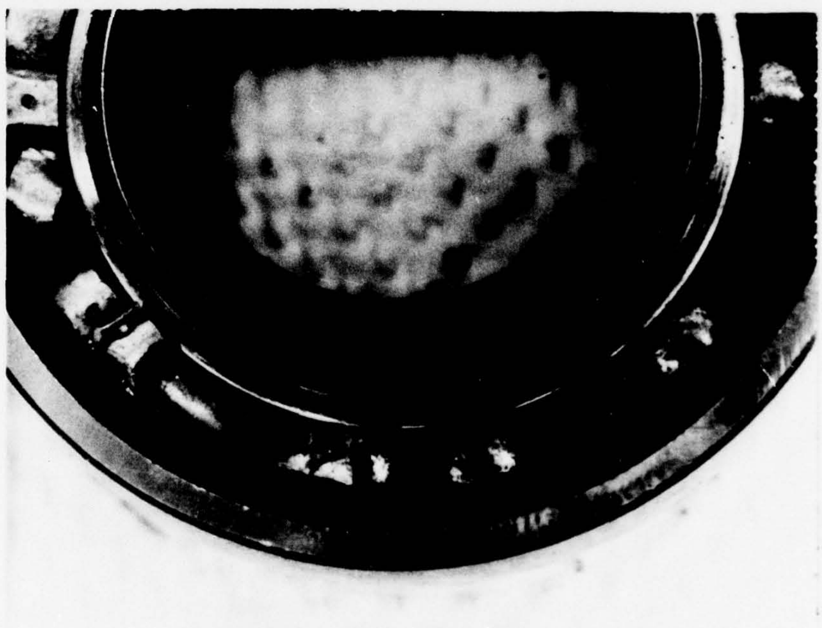

Figure 50. Bearing S/N TRL-17.
2.5x Enlarged View.

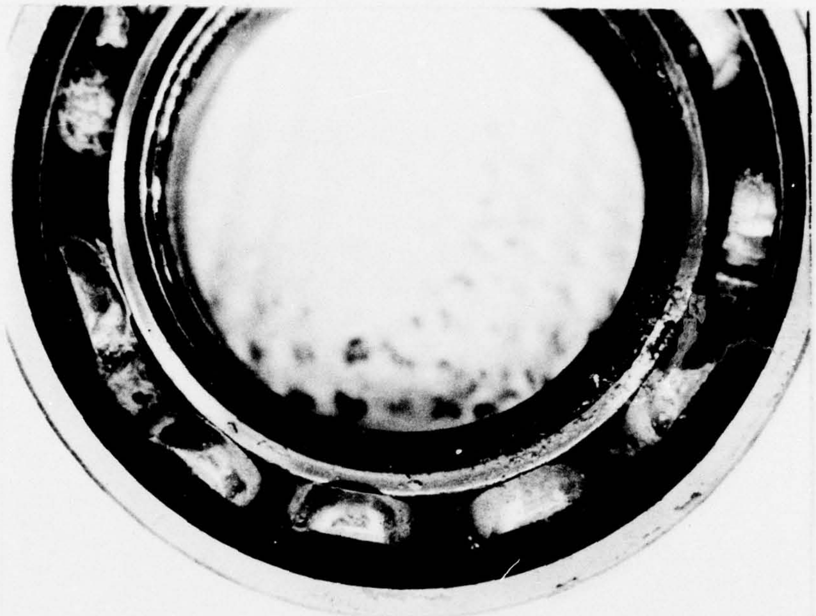

Figure 51. Bearing S/N TRL-19. Removed Position 4 With 16.6 Hours Time. 2.5x Enlarged View.

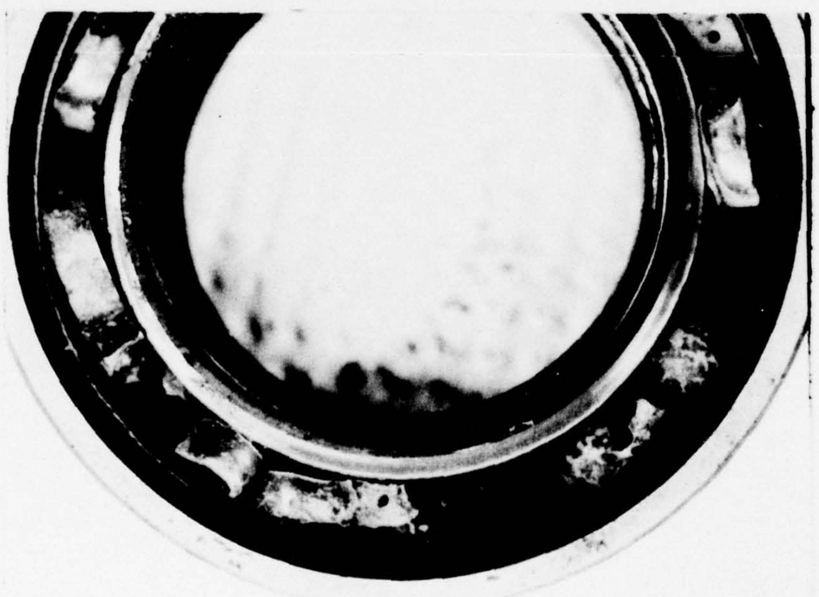

Figure 52. Bearing S/N TRL-19. 2.5x Enlarged View.

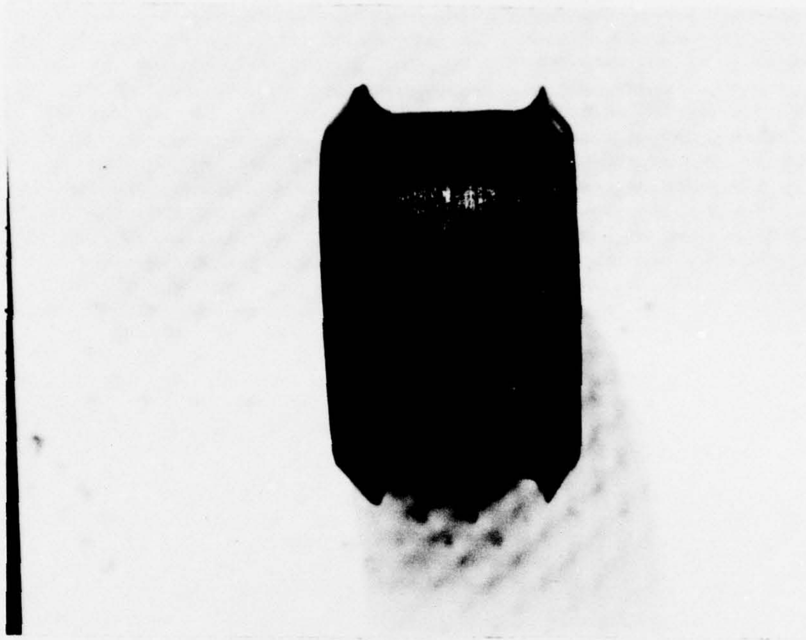

Figure 53. 206-040-315-1 Collar Removed From Bearing S/N TRL-19.

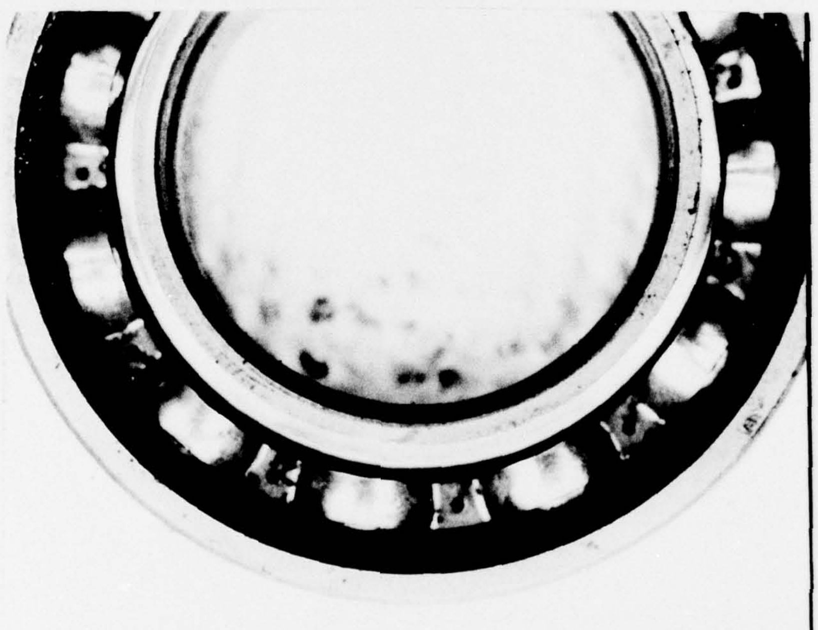

Figure 54. Bearing S/N TRL-20. Removed Position 6 With 5.6 Hours Time. 2.5x Enlarged View.

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MODEL 206 PAGE A-19

RPT 206-097-005

Figure 55. Bearing S/N TRL-21. Removed Position 8 With 5.6 Hours Time. 2x Enlarged View.

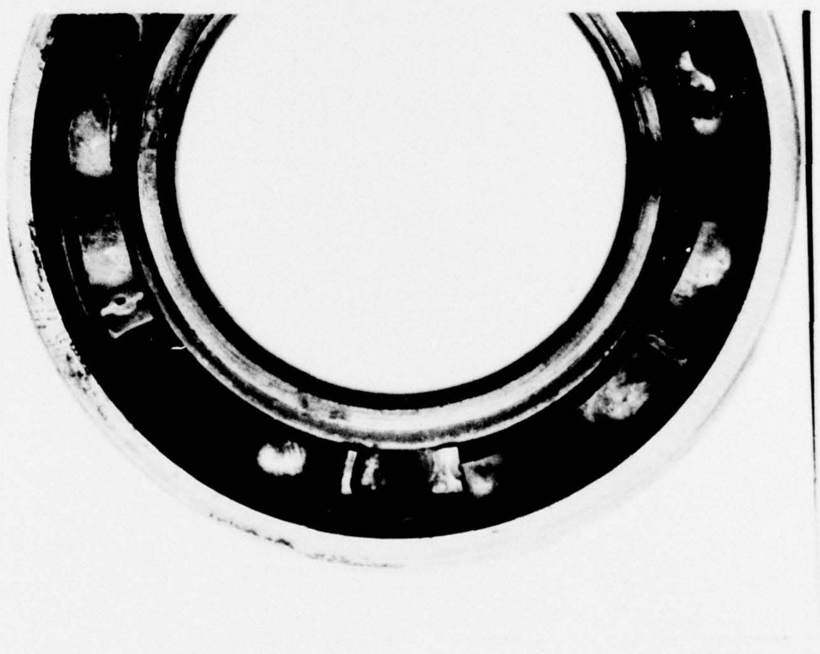

Figure 56. Bearing S/N TRL-22. Removed Position 3 With 29.4 Hours Time. 2x Enlarged View.

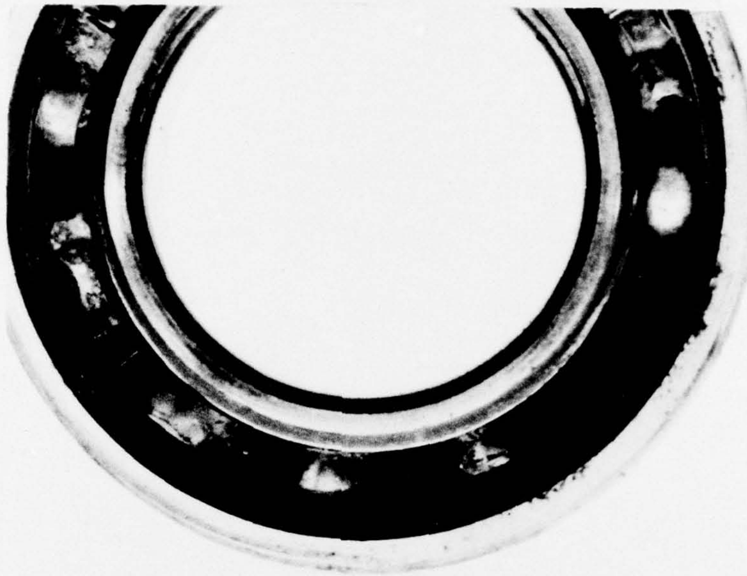

Figure 57. Bearing S/N TRL-22.
2x Enlarged View.

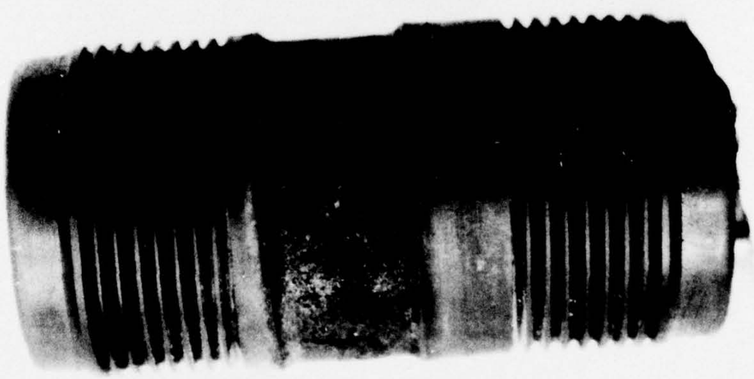

Figure 58. 206-040-350-1 Collar Removed
From Bearing S/N TRL-22.

Figure 59. Bearing S/N TRL-23. Removed Position 4 With 4.0 Hours Time. 2x Enlarged View.

Figure 60. Bearing S/N TRL-24. Removed Position 6 With 4.0 Hours Time. Shown With Seal Intact.

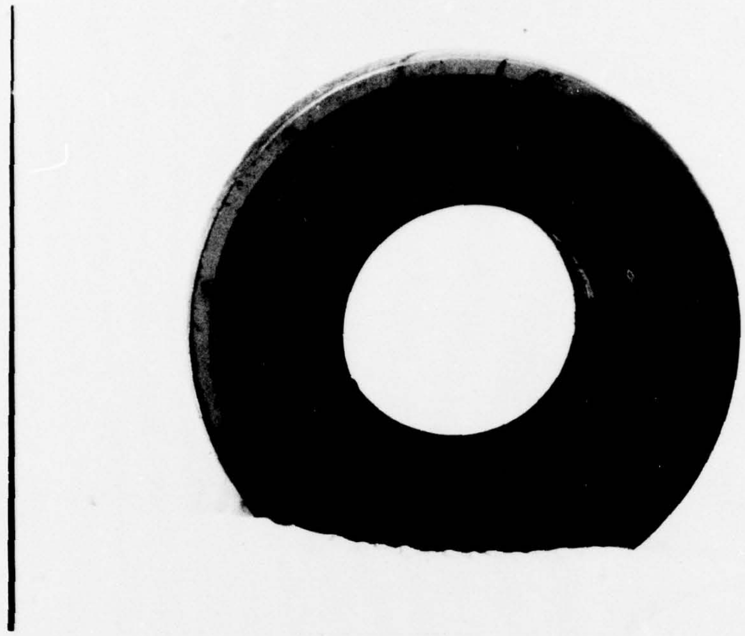

Figure 61. Bearing S/N TRL-24. View of Opposite Side Seal.

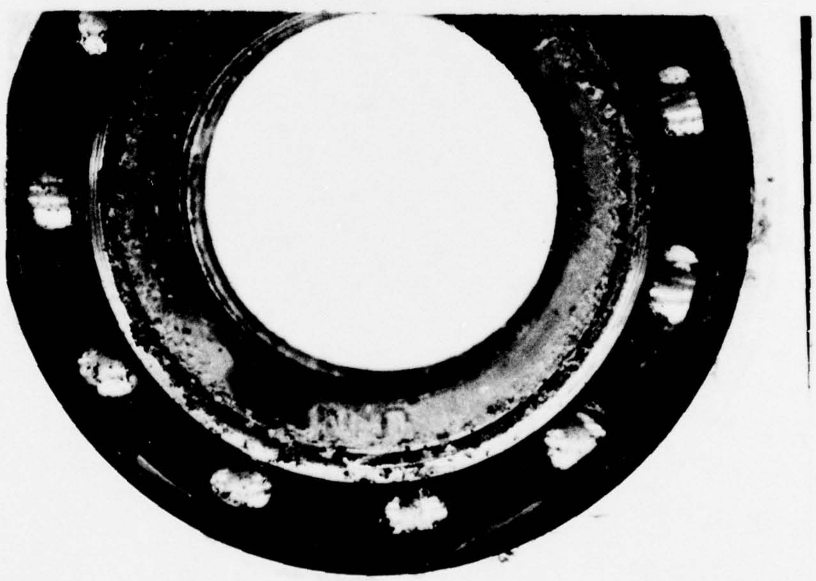

Figure 62. Bearing S/N TRL-24. 2x Enlarged View.

Figure 63. Bearing S/N TRL-25. Removed Position 8 With 4.0 Hours Time. 2x Enlarged View.

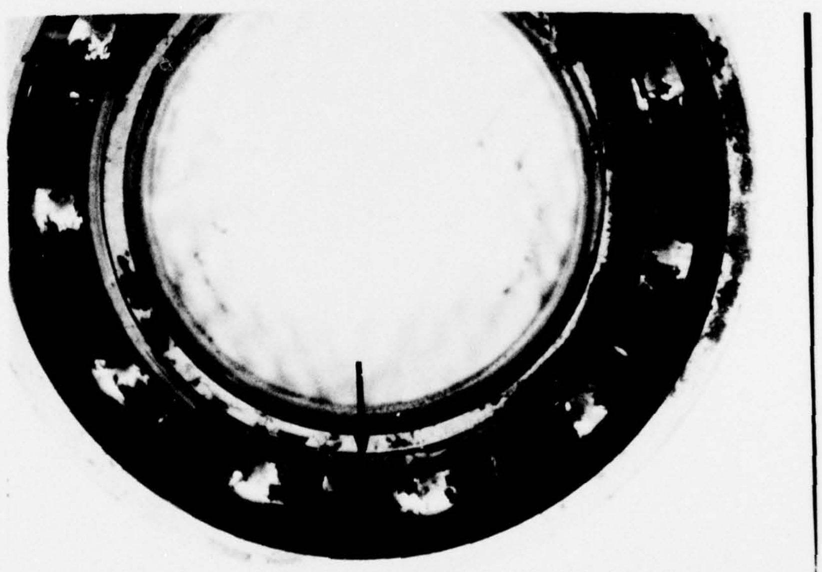

Figure 64. Bearing S/N TRL-26. Removed Position 7 With 11.0 Hours. 2x Enlarged View. Note Crack in Cage.

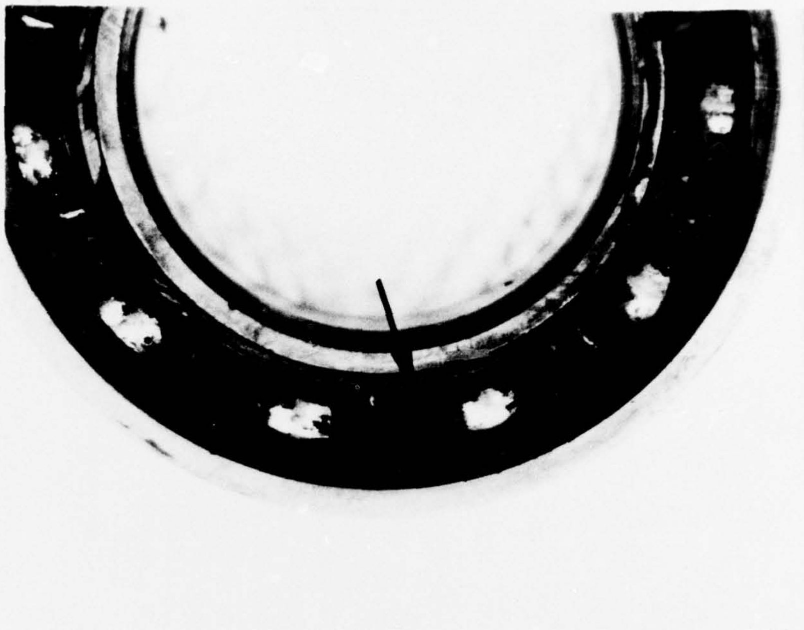

Figure 65. Bearing S/N TRL-27. Removed Position 8 With 14.5 Hours Time. 2x Enlarged View. Note Crack in Cage.

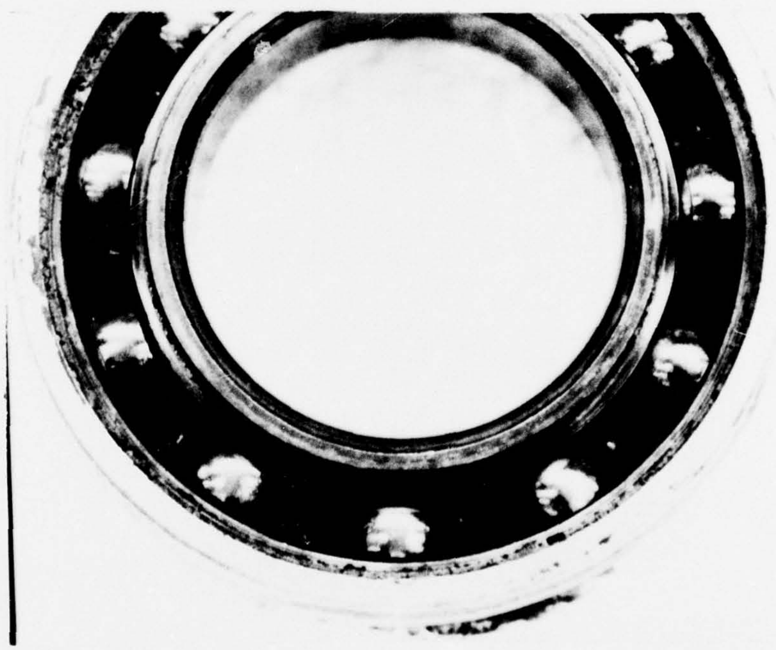

Figure 66. Bearing S/N TRL-30. Removed Position 6 With 40.7 Hours Time. 2x Enlarged View.

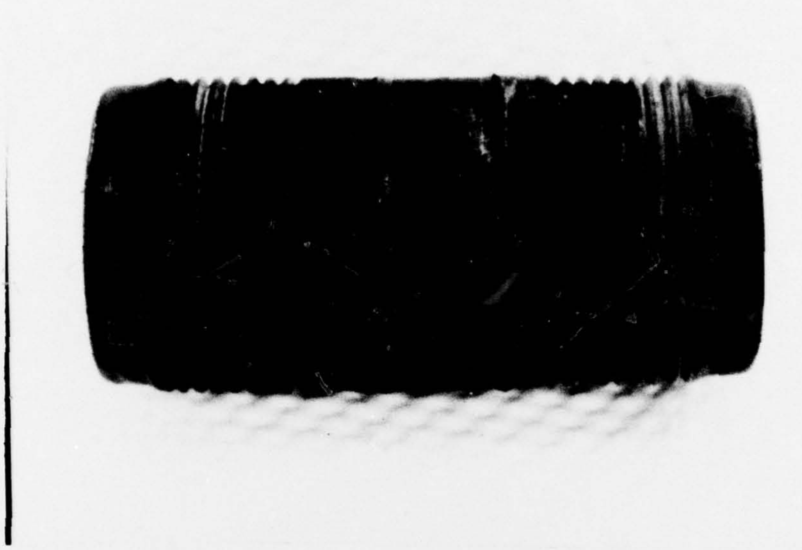

Figure 67. 206-040-350-1 Collar Removed From Bearing S/N TRL-30.

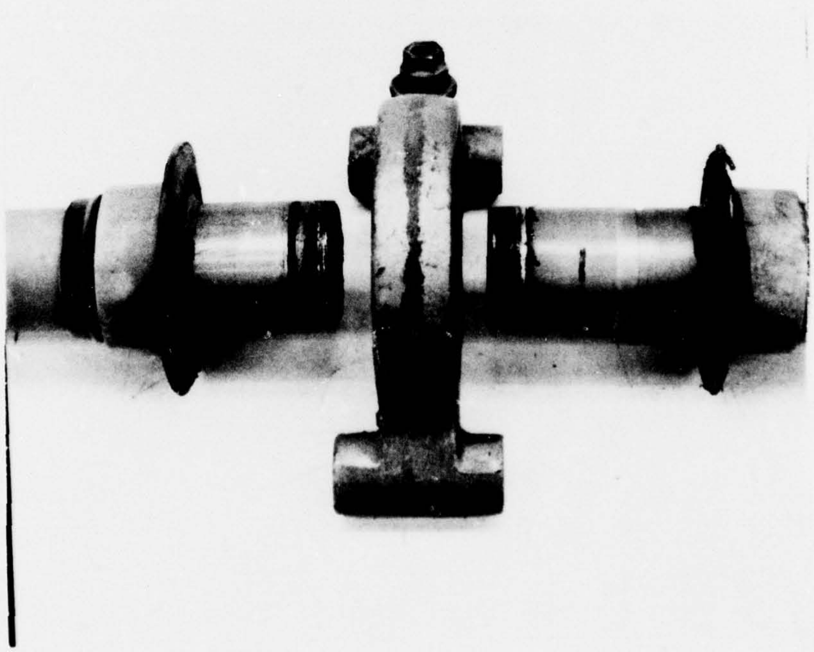

Figure 68. Bearing S/N TRL-31. Removed Position 5 With 42.5 Hours Time. Shown as Removed From Tester.

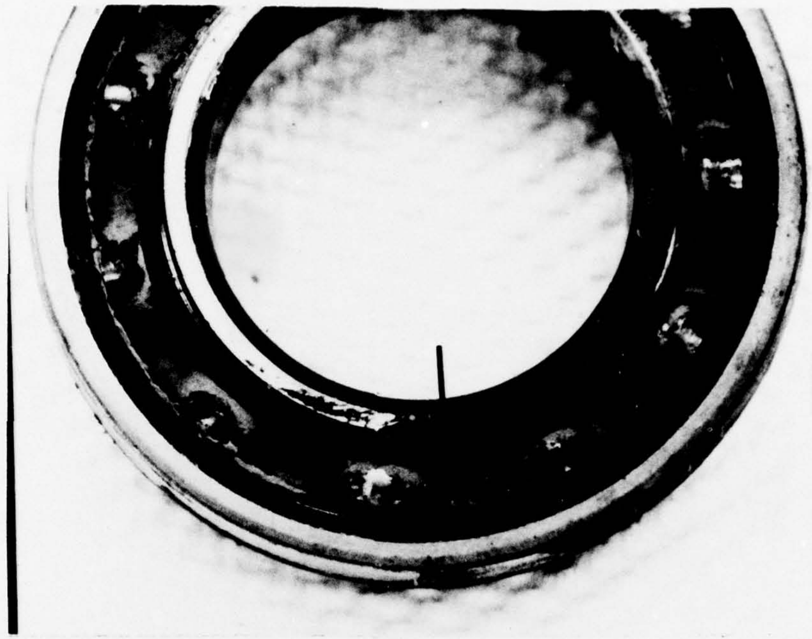

Figure 69. Bearing S/N TRL-31. 2x Enlarged View. Note Crack in Cage.

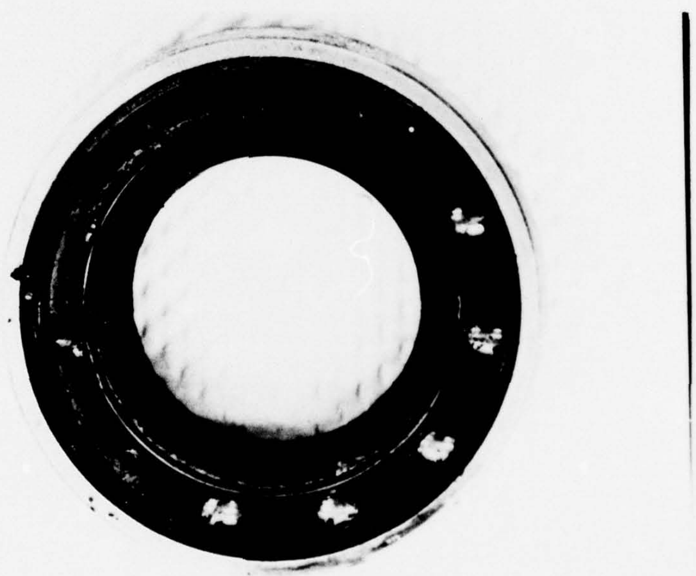

Figure 70. Bearing S/N TRL-33. Removed Position 4 With 45.5 Hours Time. Shown With Seal Plate Removed.

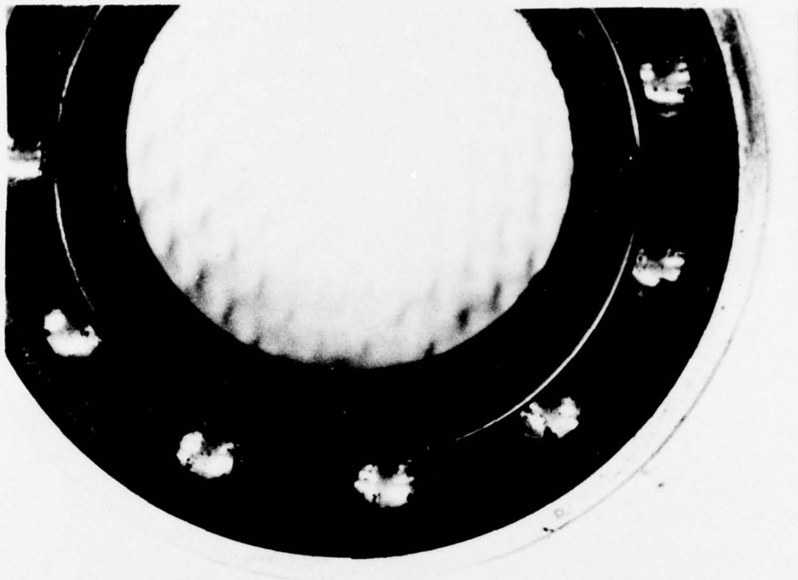

Figure 71. Bearing S/N TRL-33.
2x Enlarged View.

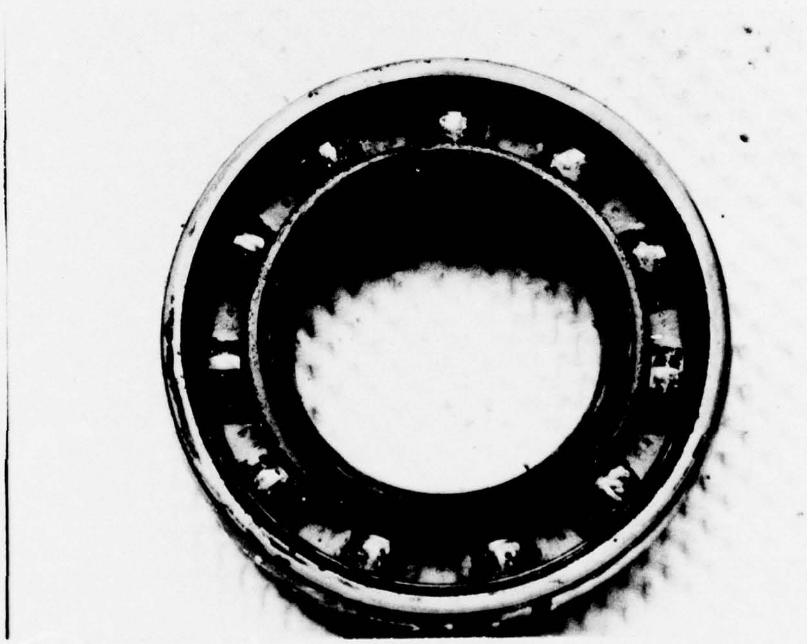

Figure 72. Bearing S/N TRL-40. Removed Position 3
With 64.4 Hours Time. Shown With Seal
Removed.

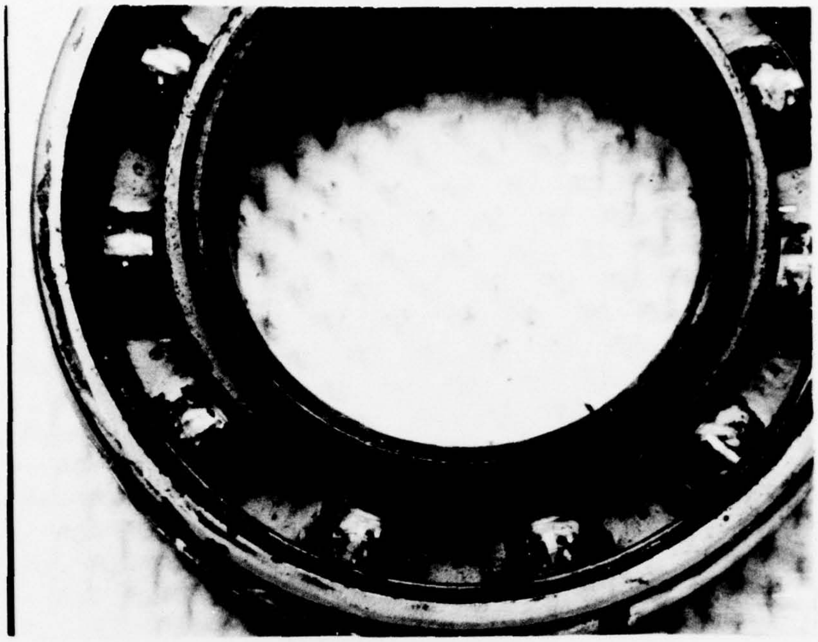

Figure 73. Bearing S/N TRL-40.
2x Enlarged View.

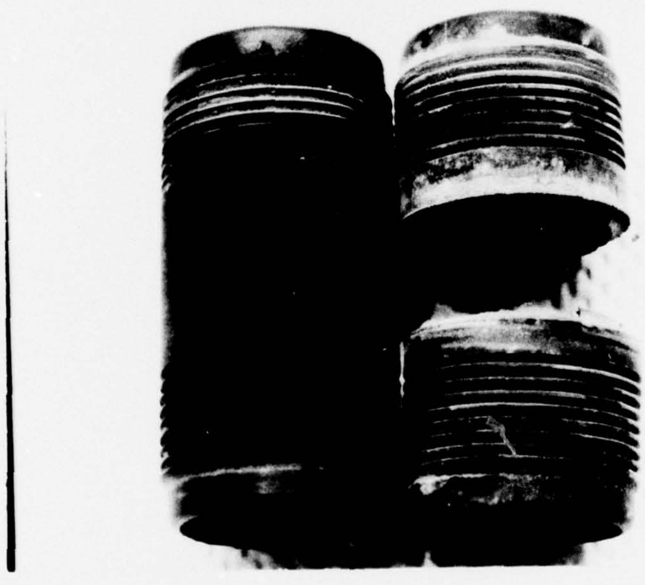

Figure 74. 206-040-350-1 Collar Removed From Bearing S/N TRL-40 (Right). New 206-040-350-1 on Left.

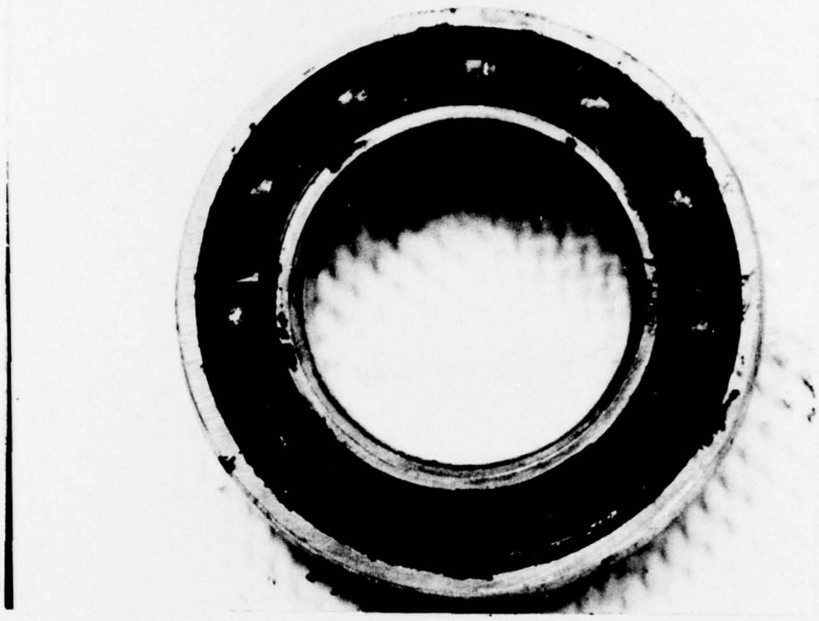

Figure 75. Bearing S/N TRL-38. Removed Position 1 With 67.4 Hours Time. Shown With Seal Removed.

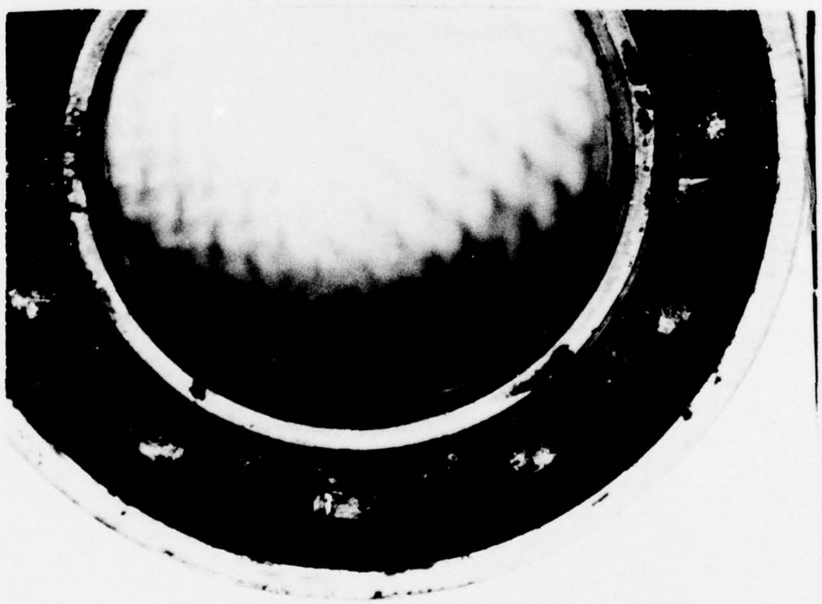

Figure 76. Bearing S/N TRL-38. 2.5x Enlarged View.

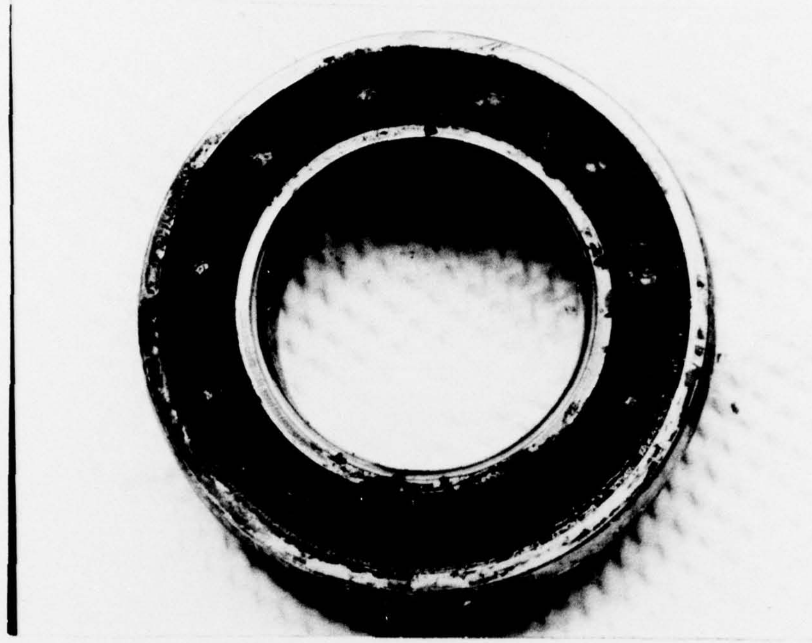

Figure 77. Bearing S/N TRL-39. Removed Position 2 With 67.4 Hours Time. Shown With Seal Removed.

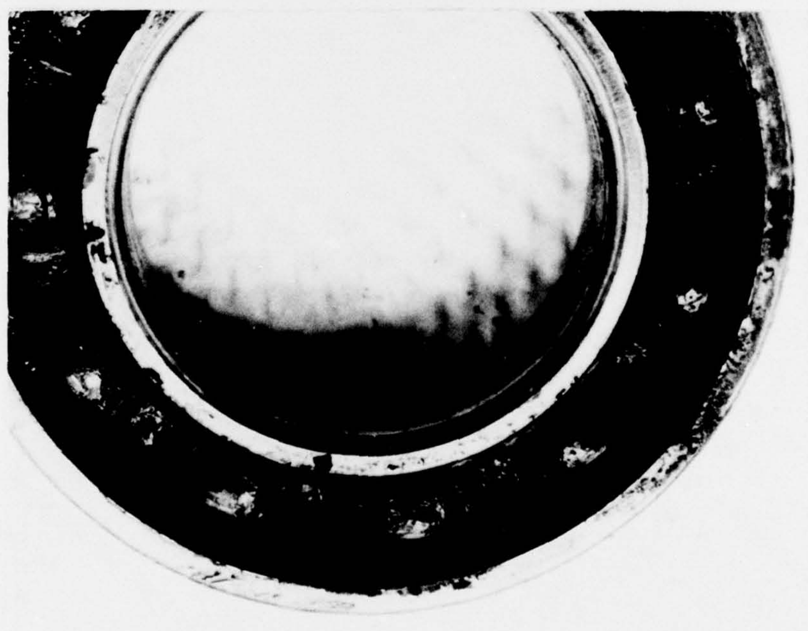

Figure 78. Bearing S/N TRL-39. 2.5x Enlarged View.

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